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New York State Agricultural Experiment Station

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CURRENT CONTRIBUTIONS ON INSECT CONTROL

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ROYAL BOTANIC GARDENS
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INTRODUCTION

THE purpose of this bulletin is to make available new results of certain current work of timely interest to the growers and agricultural workers of New York and to scientific workers generally. In the past, numerous requests have been received for information concerning investigations of general interest prior to the final completion of the projects and the publication of completed results. This bulletin attempts to meet such requests by presenting phases of current work which have reached a stage where they may properly be discussed or where an interest has been sufficient to indicate the desirability of a statement of progress even tho no final conclusions are yet possible. No attempt is made to give a full report of the recent work of the Division of Entomology.

PRESENT STATUS OF THE MINERAL OIL TREATMENT FOR CORN EAR WORM CONTROL[1]

L. A. CARRUTH, *Associate in Research* (*Entomology*)

THE corn ear worm, *Heliothis armigera* Hübner, continues to be a major pest of sweet corn in New York, particularly on Long Island, and to some extent in other parts of the State. Until very recently no satisfactory method for controlling this insect has been known. With the development of the mineral oil treatment a definite advance has been made, altho care is needed to achieve satisfactory results.[2]

The oil is applied to the "silk channel" between the cob and the exterior of each developing sweet corn ear shortly after the completion of pollination. Altho tests have indicated that a number of oils were effective experimentally, it has been found that a mineral oil of U.S.P. grade having a viscosity between 175 and 210 seconds (Saybolt 100° F) is at present most suitable for general use. Lighter oils have produced retardation of ear tip development under practical conditions. The degree of ear worm control was found to be increased very significantly by the addition of an insecticide to the oil. Pyre-

[1]A general discussion of the corn ear worm and its control is given in Circular No. 190 (1940) of this Station.

[2]A detailed investigation of the mineral oil treatment for corn ear worm control is reported in a paper by the writer appearing in the *Journal of Economic Entomology*, Vol. 35, 1942.

thrum or dichlorethyl ether has been found effective for this purpose. The standard insecticide concentrations in the finished oil-insecticide mixtures offered for sale have been 0.2 per cent pyrethrins or 2 per cent dichlorethyl ether, altho recent tests have shown that half these strengths can probably be used with essentially the same results. A dosage of between 0.5 and 0.6 cc, applied six to seven days after the first appearance of silks, is probably sufficient.

Altho reasonably satisfactory results have been obtained with the mineral oil treatment under experimental conditions, the results obtained by growers have frequently been disappointing despite the satisfactory control of the corn ear worm that has usually been secured. The principal difficulty has been the use of excessive dosages which have prevented the normal development of the tip kernels of the treated ears. Such stunting is probably not objectionable when only the kernels within an inch of the ear tips are affected, altho, unfortunately, an average tip stunting of from 2 to 3 inches has usually resulted.

Even more serious than tip stunting have been the effects produced by excessive amounts of insecticides. An objectionable odor is usually present in the harvested ears which have received an excess of an oil-pyrethrum mixture, while large dosages of oil-dichlorethyl ether mixtures have usually produced discolored ear tips. Fortunately, these difficulties can be eliminated thru the use of satisfactory equipment and greater care in application.

Another source of injury has been the treatment of ears before the completion of pollination. When an oil fortified with an insecticide is used, treatments can be safely delayed until approximately one week after silking. At this time the tips of the silks have begun to dry and, under normal conditions, pollination should have been completed. Because of the natural variation in the time of silking, even in hybrid sweet corn, two periods of treatment are usually necessary to reach all ears at the proper time. A simple marking system, such as the removal of a certain leaf, is desirable to prevent treating some ears twice.

To insure adequate equipment for this treatment it may still be necessary to resort to homemade devices since, during 1941, no entirely satisfactory commercial oil applicator was available to New York growers. The applicators offered for sale during 1941 released excessive amounts of oil per discharge and had trigger actions which were much too stiff for comfortable operation when more than a few dozen ears were to be treated. It is hoped that more satisfactory commercial applicators will be available during 1942.

An applicator consists essentially of an oil reservoir, usually a 1-gallon can carried on the shoulders in knapsack fashion, which is connected by a length of hose to a plunger-type oil-can carried in the hand. It is essential that the amount of oil discharged per trigger squeeze be accurately and permanently regulated. This can be done by means of a set-screw or some similar device. *Under no circumstances*

should more than 0.6 cc (1/50 of a fluid ounce) of oil be discharged at one time. Larger amounts are wasted and produce excessive tip stunting. The applicator can be calibrated with the aid of a glass prescription bottle having graduations to indicate 1 or more fluid ounces. The oil from 50 applicator discharges should equal exactly 1 fluid ounce. At this rate 1 gallon of material should treat 6,400 ears, or more than one half of an average acre of sweet corn.

THE STATUS OF BIOLOGICAL CONTROL OF THE JAPANESE BEETLE IN NEW YORK STATE[1]

E. H. SMITH, *Assistant in Research (Entomology)*, AND D. M. DANIEL, *Associate in Research (Entomology)*

THE Japanese beetle, *Popillia japonica* Newman, has been established in New York State for a number of years. Altho the heaviest infestations are centered in the vicinity of metropolitan New York, the insect has also spread northward and westward until it is now present over a large area in upstate New York, as indicated in the accompanying map (Fig. 1). The continued presence and spread of this insect constitute a serious threat to the agricultural interests of

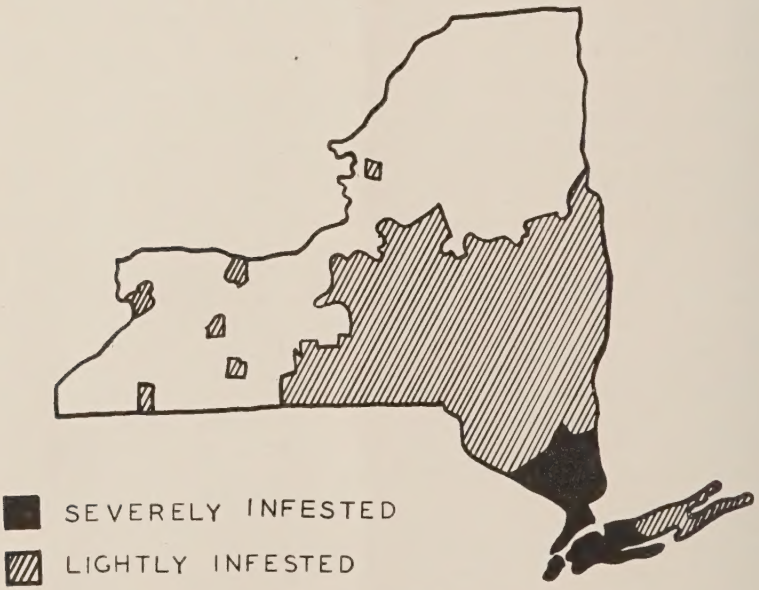

FIG. 1.—JAPANESE BEETLE INFESTATION IN NEW YORK STATE IN 1941.

The solid and lined areas indicate the portion of the State now under federal Japanese beetle quarantine.

[1]The Station has been able to extend the scope of this work thru the helpful interest and cooperation of several state agencies. Particular acknowledgment is due to the Bureau of Plant Industry, New York State Department of Agriculture and Markets, Dr. A. B. Buchholz, Director, which has generously provided additional personnel and transportation facilities. The helpful cooperation of agricultural extension workers in Westchester, Nassau, Rockland, Orange, and Ulster Counties is also acknowledged.

the State, particularly fruit growers, producers of vegetable and forage crops, nurserymen, and home gardeners.

Due to the omnivorous feeding habits of the adults and the underground habitat of the larvae, insecticidal control of the Japanese beetle is at best difficult and frequently inadequate. It has therefore been necessary to consider alternative methods of control. Of these, biological control, involving the suppression of an injurious insect by its natural enemies, has merited intensive investigation. It has been found that foreign insect pests, such as the Japanese beetle, may become exceedingly destructive when introduced into this country unaccompanied by their native natural enemies. The subsequent introduction of such native enemies may greatly reduce the economic importance of these foreign pests. The recently reduced injury of the oriental fruit moth on peaches in western New York following the release of insect parasites by this Station is a good example of effective biological control. Encouraged by such results, a similar program for the control of the Japanese beetle is now under way.

Extensive pioneer work to determine the most valuable natural enemies of the Japanese beetle has already been done by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture. In 1938 a mutually profitable cooperative working agreement was established between this federal agency and this Station. As a result of this agreement insect parasites and disease spore material, produced at the Federal Japanese Beetle Laboratory at Moorestown, New Jersey, have been made available for distribution in New York State. The actual work of selecting liberation sites, disseminating insect parasites, and measuring the results obtained in New York has, by agreement, been done by this Station with the assistance of the New York State Department of Agriculture and Markets.

The most promising natural enemies of the Japanese beetle yet available are two insect parasites and a spore-forming bacterium. Both insect parasites, *Tiphia vernalis* Rohwer and *Tiphia popilliavora* Rohwer, attack the larval stage of the host. Eggs are deposited upon beetle grubs and, upon hatching, the parasite larvae feed upon the body fluids of the host. The bacterium, *Bacillus popilliae* Dutky, invades the blood stream of the beetle larvae, producing a condition known as milky disease. Subsequently, infested larvae become chalky white and die.

Most of the work with these natural enemies has been done in the heavily infested area near New York City. For the work to date localities have been selected which offered extensive sod areas with high populations of beetle larvae and abundant food plants for the adult insect parasites. The parkways, golf courses, and estates of the metropolitan area have provided such conditions. It is believed that this work will also benefit other sections of the State which may become more seriously affected as the insect increases its range and

intensity of infestation. A summary of the work accomplished to date in the metropolitan area is shown in the accompanying map (Fig. 2).

Prior to 1938 limited numbers of insect parasites were released in

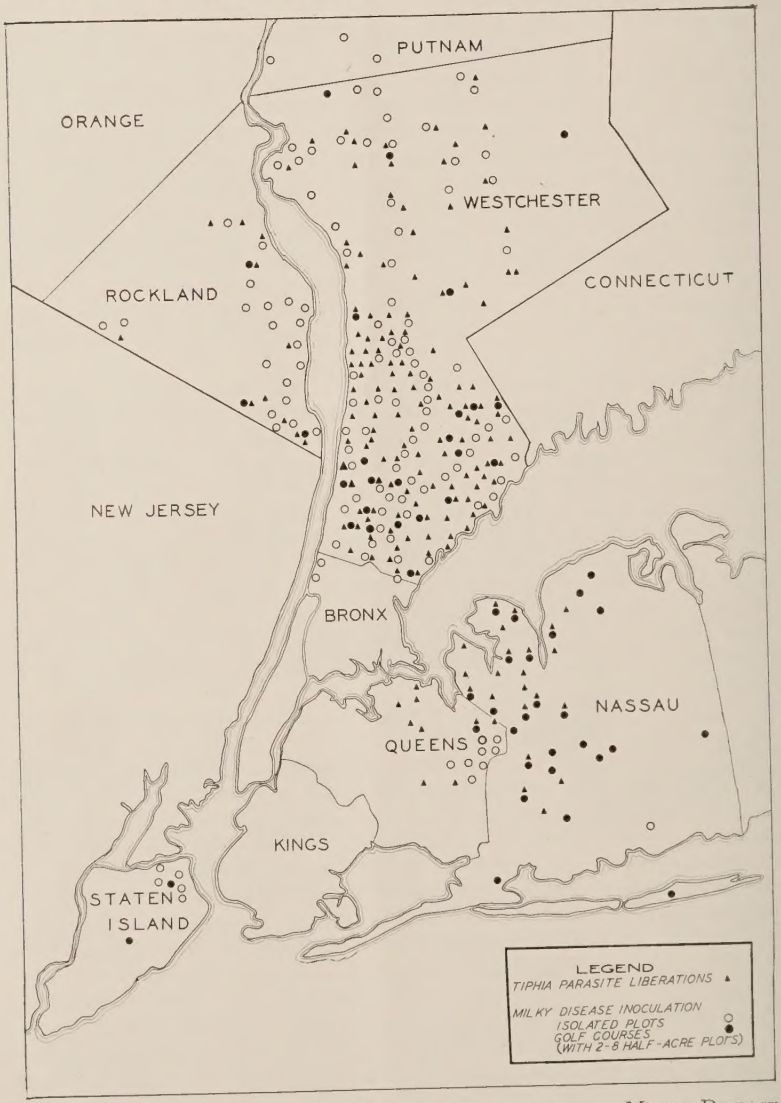

FIG. 2.—LOCATION OF SITES OF PARASITE LIBERATIONS AND MILKY DISEASE INOCULATIONS IN THE METROPOLITAN AREA.

New York State by the United States Department of Agriculture. Since 1938, this Station has released a total of 180 colonies of parasites, each consisting of 100 mated females, as follows:

Year	Species	Number of colonies
1938	*T. popilliavora*	12
1939	*T. popilliavora*	19
1939	*T. vernalis*	50
1940	*T. vernalis*	50
1941	*T. vernalis*	49

Preliminary observations have already indicated that these two species of parasites are definitely capable of establishing themselves under the environmental conditions encountered in this State.

In 1938 a survey in the metropolitan area revealed no indication of the presence of milky disease. Beginning in 1939, spore dust material, containing the milky disease organism, has been distributed in the area of heaviest infestation. By the close of the season of 1941 a total of 373 plots, comprising over 186 acres, had been treated. In 1940 a total of 412 pounds of spore dust was prepared by the Moorestown Laboratory from 20,000 Japanese beetle grubs collected and inoculated by New York State workers. In 1941, 100,000 grubs were collected and sent to Moorestown for inoculation and processing with chalk dust and talc. In 1941 a survey of milky disease plots treated in 1940 showed conclusively that the disease had become well established. Systematic larval collections are being made regularly from a series of experimental plots established in 1940 in order that the progress of the milky disease may be followed closely. Surveys of a more general nature are also being made in the area of continuous infestation to follow changes in the population of the beetle.

Much work remains to be done before the ultimate value of biological control methods can be determined. Several years will be required for the natural enemies already introduced to become sufficiently abundant to exert an appreciable effect. The favorable results already observed in preliminary surveys have emphasized the value of this work and the desirability of its continuance in the infested areas of New York State.

PYRETHRUM DUSTS FOR THE CONTROL OF THE APPLE REDBUG

R. W. DEAN, *Assistant in Research (Entomology)*

EXPERIMENTS conducted in eastern New York for the past several years have been directed toward finding a contact insecticide to replace nicotine sulfate in the calyx spray for the control of the apple redbug (*Lygidea mendax* Reut.). Objections to the use of nicotine sulfate have been its cost, its loss of effectiveness at low temperatures, and its toxicity to some spray operators. The most promising substitute found has been pyrethrum. It was first used in the form of ground powdered pyrethrum flowers which were substituted for nicotine in the calyx spray. This form of pyrethrum proved cheaper but less effective than nicotine in controlling the redbug. It was found that much of the insecticidal activity of the powder was lost when it was combined with a wettable sulfur fungicide, and even more when used with liquid lime-sulfur. The more expensive pyrethrum extracts were next tried. These gave better control of the redbug, sometimes exceeding that obtained with nicotine sprays, but the objection to combining pyrethrum with alkaline fungicides remained. Experiments were then planned to test the efficiency of pyrethrum in dust form. The results of tests conducted during 1938, 1940, and 1941 are summarized in Table 1 and in the discussion.

In 1938, in a heavily infested block of McIntosh trees, the pyrethrum compound was combined with lead arsenate, sulfur, and clay, but this mixture was found too heavy to possess good dusting properties. In 1940, pyrophyllite was substituted for clay to increase bulk and lightness of the mixture. In 1941, the sulfur and lead arsenate were omitted and the dust applied a few days after the calyx spray, as is recommended when nicotine dust is used.

In 1938 the pyrethrum dust was nearly as effective as the nicotine spray and considerably better than several sprays containing pyrethrum powder. Since the nicotine dust was only half the recommended strength, it gave poorer control than either of the other two treatments shown. In 1940, the tests were conducted in a badly infested orchard of large McIntosh trees. Both dusts proved more effective than the spray treatment, probably due to the better coverage of the large trees by the dust treatments. In 1941, all three pyrethrum dusts tested gave control equal to or better than that given by the nicotine spray. Temperatures were relatively low when all treatments were made which probably accounts for the poor control obtained with the nicotine-lime dust.

In 1941, a crop failure in the test block of McIntosh trees made it impossible to take the usual harvest data by making fruit counts and it was necessary to use another method to determine the percentage control obtained. Accordingly, at the time of treatment, a large sheet was spread beneath one tree in each plat and all bugs knocked down

TABLE 1.—COMPARISON OF PYRETHRUM DUSTS WITH NICOTINE SPRAYS AND DUSTS FOR THE CONTROL OF APPLE REDBUG IN THE HUDSON VALLEY, 1938, 1940, AND 1941.

TREATMENT	INJURED FRUITS, PER CENT	REDBUG SURVIVAL, PER CENT	CONTROL EFFICIENCY, PER CENT
1938 Tests, Columbia County			
Untreated	29.68	——	——
1% nicotine-lime dust	11.02	——	62.87
Pyrethrum dust (0.22% pyrethrins)[1]	2.52	——	91.51
Nicotine spray[2]	1.80	——	93.93
1940 Tests, Dutchess County			
Untreated	13.45	——	——
2% nicotine-lime dust	1.00	——	92.53
Pyrethrum dust (0.2% pyrethrins)[3]	0.46	——	96.56
Nicotine spray[2]	4.60	——	65.79
1941 Tests, Dutchess County			
Untreated	——	100.00	——
2% nicotine-lime dust	——	58.23	41.77
Pyrethrum dust (0.15% pyrethrins)[4]	——	1.73	98.26
Pyrethrum dust (0.2% pyrethrins)[5]	——	0.00	100.00
Pyrethrum-tobacco dust mixture (0.125% pyrethrins, 0.125% nicotine)[6]	——	0.77	99.23
Nicotine spray[7]	——	1.77	98.22

[1]"Dry Pyrocide" (2% pyrethrins), 10 lbs.; lead arsenate, 10 lbs.; sulfur, 40 lbs.; clay, 30 lbs.
[2]Lime-sulfur, 2 gals.; lead arsenate, 3 lbs.; hydrated lime, 3 lbs.; nicotine sulfate, 1 pt.; water to make 100 gallons.
[3]"Dry Pyrocide", 10 lbs.; lead arsenate, 10 lbs.; sulfur, 50 lbs.; pyrophyllite, 30 lbs.
[4]"Dry Pyrocide", 7½ lbs.; pyrophyllite ("Pyrax ABB"), 92½ lbs.
[5]"Dry Pyrocide", 10 lbs.; pyrophyllite ("Pyrax ABB"), 90 lbs.
[6]"Stimtox A" (0.5% pyrethrins), 25 lbs.; snuff-mill sweepings, 74¾ lbs.; "Aresket", ¼ lb.
[7]Nicotine sulfate, 1 pt.; hydrated lime, 3 lbs.; water to make 100 gallons.

by the spray or dust were collected. From 8 to 11 days later these same trees were sprayed with double-strength nicotine and any bugs not killed by the original treatment were knocked down and collected from the sheet. From these data the percentage control efficiency was calculated.

In conclusion, it may be said that pyrethrum, when applied as a dust, has given better control of the apple redbug than when used as a spray and has been more consistently effective than nicotine sulfate in either spray or dust form. Pyrethrum dusts have controlled the redbug when applied at temperatures too low for the effective use of nicotine. They are relatively non-toxic to humans.

Unfortunately, at the present cost of pyrethrum, the cheapest pyrethrum dust costs nearly twice as much as a home-made 2 per cent nicotine-lime dust. It is therefore probable that, for the present, nicotine sprays or dusts for redbug control will be preferred by most growers except in cases where spray operators are sensitive to nicotine or when cool weather prevents nicotine treatments from being fully effective.

THE USE OF CONCENTRATED SPRAYS FOR PEA APHID CONTROL[1]

HUGH GLASGOW, *Chief in Research* (*Entomology*)

DURING the past five years as part of the Station's pea aphid research program, studies have been carried out to determine the practicability of using concentrated sprays for the control of this pest. A method was sought which would give passable control of the pea aphid and yet avoid some of the weaknesses which have rendered ordinary spraying all but obsolete. After two years experience with the application of concentrated sprays by airplane, the control with this type of equipment did not seem to justify its continued use, even tho mechanically, the airplane has many outstanding advantages over ground machines. The emphasis in more recent work has therefore been directed largely to the use of ground-operated machines.

FIG. 1.—THE SNIDER SPRAYER, SHOWING BOOM DESIGNED FOR APPLYING CONCENTRATED SPRAYS TO CANNERY PEAS FOR CONTROL OF PEA APHID.

During the course of the work there was abundant opportunity for observing the performance of a number of commercial "atomizers," some of which appeared very promising. The results considered below, however, are based on the performance of a machine built locally by the Snider Packing Corporation. This machine was improved and modified from year to year as the work progressed.

Unlike most so-called "atomizers" this machine is operated by direct pressure from a standard spray unit. Since the spray as delivered by this machine is very finely divided and lacks any supplementary air blast to provide carrying power, it was found necessary to design a boom fitted with special nozzles as shown in Fig. 1. The

[1]This phase of the Station's pea aphid control investigations has been conducted almost entirely in cooperation with the Snider Packing Corporation. It is largely because of the eagerness of the men in this organization to find some rapid and reasonably effective means for fighting the pea aphid that the studies on this aspect of the problem have been followed thru so persistently.

nozzles were arranged in such a fashion that the boom could be carried close to the peas during the operation of spraying. It was also found desirable to protect the boom with a metal hood when oil sprays were applied and to use a canvas trailer in addition to the metal hood when water-borne sprays were applied.

The results of one typical series of field trials with concentrated sprays, conducted during 1941, are summarized in Table 1.

These results are an example of the degree of control that has frequently been secured by this method of treatment when applications are made under favorable conditions. The experiment summarized in Table 1 utilized the bulk of a 20-acre field of Perfection peas. The

TABLE 1.—THE EFFICIENCY OF CONCENTRATED SPRAYS AS MEASURED BY PEA APHID CONTROL, 1941.

TREATMENT*	DOSAGE PER ACRE	OPERATING SPEED, MILES PER HOUR	PEA APHID POPULATION ONE WEEK AFTER TREATMENT†	PERCENTAGE APHID REDUCTION
Vapofumer (80 per cent free nicotine)	3 lbs.	1	207	92.7
One per cent rotenone dust	45 lbs.	1	589	79.3
Concentrated spray:				
No. 1 (water-borne)	20 gals.	5	576	79.8
No. 2 (water-borne)	20 gals.	5	383	86.5
No. 3 (oil-borne)	5 gals.	5	172	94.0
Untreated		–	2,848	

*The insecticides were prepared as follows: The 1 per cent rotenone dust contained 2 per cent soybean oil with pyrophyllite as the carrier. Concentrated spray No. 1 contained 96¼ gallons of water plus 3¼ gallons of rotenone extract containing 2½ per cent rotenone. Concentrated spray No. 2 contained 96 gallons of water, 1⅞ gallons of Black Leaf 40, and 18 pounds of soap. Concentrated spray No. 3 contained 89½ gallons of oil (viscosity 35 seconds), 1½ gallons of 80 per cent free nicotine, and 9 gallons of rotenone extract containing 2½ per cent rotenone.

†By pea aphid population is meant, in all cases, the number of individuals of all ages actually collected in 10 sweeps of an 11-inch beating net equipped with a 26-inch handle.

field was divided into six sections, five of which were treated. The sections treated by the Vapofumer (nicotine vaporizer) and the standard 1 per cent rotenone dust were included to serve as an additional basis for comparison. Applications were not begun until the aphid population had reached a critical stage as indicated by a count of over 5,000 aphids taken in 10 strokes of the net. The counts shown in Table 1 were made on June 18, 9 days after the applications were completed, and show the apparent reduction in aphid population as a result of the various treatments. It should be noted that the general aphid population level in this field dropped during this 9-day interval and that, as frequently happens, this decrease continued progressively as the season advanced. In this test the concentrated sprays all performed well in comparison with the standard treatments, even tho the use of a trailer was omitted where the water-borne sprays were used.

In conclusion, it may be stated that certain concentrated sprays, when carefully applied, have often given a surprisingly high kill of the pea aphid, not only in experimental blocks but also in the hands of experienced canners. While this method of application has by no means been finally perfected, either as to the most effective insecticide combinations or the equipment best adapted for applying them, the results so far have been promising enough to merit further serious consideration. Unquestionably, there are still glaring weaknesses in this method. However, when the advances that have been made in the past few years, particularly in the development of equipment adapted to this form of application, are taken into account, it seems likely that concentrated sprays will eventually be given a real place in the general pea aphid control program.

BLOOD ALBUMIN FOR USE AS AN EMULSIFIER

G. W. PEARCE, *Associate in Research (Chemistry)*, AND P. J. CHAPMAN, *Chief in Research (Entomology)*

BLOOD albumin was first widely used in New York in 1941 as an emulsifying agent for tank-mixed oil sprays for the control of insects on fruit trees. It was selected from a number of possible emulsifiers, first, because of its desirable emulsifying properties, but also for its moderate cost, availability, and ease of handling. In contrast to lignin pitch (Goulac, Binderine Flour), which has been commonly used for a number of years, blood albumin enables the grower to reduce the amount of oil in the spray mixture. This is possible because of the greater oil-depositing qualities imparted to the spray mixture by the albumin. For example, for killing eggs of the fruit-tree leaf roller, a 6 per cent oil spray has been advised when emulsions are prepared with Goulac. When blood albumin is used, however, a 4 per cent oil spray is adequate.

It is essential that the proper amount of blood albumin be used. An excessive quantity may result in run-off, with a decrease in the amount of oil deposited and a consequent decrease in insect control. The effects produced on oil deposit by varying the amount of albumin are illustrated in Table 1.

TABLE 1.—EFFECT OF VARYING THE AMOUNT OF ALBUMIN ON THE AMOUNT DEPOSITED FROM A 4 PER CENT OIL SPRAY MIXTURE.

AMOUNT OF BLOOD ALBUMIN USED PER 100 GALLONS OF SPRAY	QUANTITY OF OIL DEPOSITED PER SQUARE INCH OF APPLE BARK, MILLIGRAMS
1 ounce (4 ozs. albumin+filler)	2.62
2 ounces (8 ozs. albumin+filler)	2.43
4 ounces (16 ozs. albumin+filler)	1.50

These and other similar data are interpreted as showing that 2 ounces of blood albumin is the proper amount to use in preparing 100 gallons of a tank-emulsified oil spray.

For greater ease in handling, commercial preparations of blood albumin are usually diluted with an inert substance, such as diatomaceous earth. The common formula is 1 part by weight of blood albumin to 3 parts by weight of diluent. Thus, to obtain 2 ounces of actual blood albumin, it would be necessary to use 8 ounces of such a commercial mixture.

There is a danger of confusing blood albumin suitable for the emulsification of oil sprays with other products derived from blood, such as dried blood and blood meal, which have practically no value for this purpose. The following specifications for an acceptable grade of blood albumin are therefore presented:

Soluble Dried Blood (Grade A Powdered Blood Albumin)
Total nitrogen..... 14.0 ± 0.5 per cent
Solubility..... Not less than 90 per cent soluble in water
Fineness... Not less than 90 per cent to pass a 100-mesh screen

These specifications apply to blood albumin alone and not to inert products incorporated as fillers. Of the latter, diatomaceous earth appears to be the preferred material.

Until the present, the use of blood albumin has been largely limited to the emulsification of oil sprays applied to fruit trees during dormant and semi-dormant periods. Recents tests show, however, that it is also a satisfactory emulsifier for the tank-mixing of summer oils. It may be used for this purpose at the same strength indicated above (2 ounces of actual blood albumin per 100 gallons of spray). Like many other emulsifying materials, blood albumin may also find uses as a wetting and spreading agent with spray mixtures other than those containing oil. Where blood albumin is employed for this purpose, the same grade of material is advised. The same quantity used in oil sprays will probably give desirable wetting and spreading effects on most plant surfaces.

CONTRIBUTIONS TO CODLING MOTH CONTROL

S. W. HARMAN, *Associate in Research (Entomology)*

SHORTENING THE CODLING MOTH SPRAY PROGRAM

RECENT experiments have shown that it is possible to limit the summer apple spray program to those sprays required for first brood control. In western New York such a schedule would require spraying from about mid-June to mid-July. The second brood or late summer sprays are not required for the reason that a complete kill of the first brood eliminates the danger of a second brood attack. This program has been used at this Station in a Rhode Island Greening orchard for the past five years. Every second year the summer sprays have been omitted for the purpose of building up a heavy infestation of the codling moth for the test the following season. Each year the orchard was sprayed the crop has been over 99 per cent free of insect injury, while in the alternate years the fruit has been practically a total loss from codling moth attack.

Requisites for successful first brood annihilation spraying are as follows:

1. A well-pruned orchard with trees spaced to allow for rapid and thoro spraying.
2. Fruit thinned when necessary.
3. Modern spray equipment, preferably with lights for night spraying.
4. Equipment sufficient to cover an entire planting in two to three days.
5. The application of sprays every week or 10 days in heavily infested orchards during the period of first brood activity.
6. Well-kept adjoining orchards or about 200 yards of open field between plantings to prevent re-infestations.

During periods of inclement weather night spraying may be advantageous. It often affords dead calm conditions which permit sprays containing nicotine to produce a fumigation effect that is seldom possible in daylight. The toxic fumes hang in the trees for long periods seemingly killing all active insect life. After such a treatment it is usually a week or 10 days at least before insect life becomes reestablished. Contact sprays, such as oil and nicotine, are especially well adapted for annihilation spraying as moths, eggs, and exposed and recently entered larvae are all likely to be destroyed.

The summer spray program usually consists of a calyx and one or two cover sprays with lead arsenate followed by oil and nicotine until danger from first brood attack has passed. Where this program has been carried out faithfully and the first brood of worms eliminated, no further spraying has ordinarily been found necessary.

EXPERIMENTS WITH ROTENONE AND OTHER ORGANIC INSECTICIDES

Of the several organic insecticides in common use at the present time, nicotine has unquestionably given most promise as a control for the codling moth. Many years elapsed, however, after nicotine was first employed as an insecticide before methods were perfected to the point where it was accepted as a satisfactory control for the codling moth. Nicotine sprays as they are used today give equally good control and, in some cases, are even preferable to the standard lead arsenate sprays.

In the past, rotenone sprays have been found highly toxic to a wide range of insects, but attempts to apply these materials in codling moth control have not been very encouraging. After considering the advances that have been made with nicotine sprays as a result of improved technics, it seemed possible that improvements might be made in the performance of rotenone and other organic insecticides against the codling moth. It was this belief that has encouraged the retention of rotenone, pyrethrum, and certain other organic insecticides in our general codling moth research program even tho the results of the first tests have often been far from promising.

Beginning in 1938, several different rotenone extracts as well as powdered rotenone-bearing roots have been tested repeatedly under conditions of heavy codling moth infestation. Invariably the extracts were found to be inferior to the powdered root and of questionable value. It was difficult to secure a satisfactory deposit of the powdered root on apples without the addition of a spreader and sticker, but when a suitable supplement was used the powdered root compared favorably with either nicotine or lead arsenate sprays for codling moth control. When applied in combination with 1 quart of summer oil and 1 pound of lead arsenate, 2½ pounds of the powdered root (4.8 per cent rotenone) in 100 gallons gave 99.1 per cent efficiency in worm control. This was superior to all other treatments, including both nicotine and lead arsenate schedules. A spray combining a rotenone-bearing root with a reduced amount of lead arsenate appears to have real possibilities for use against the codling moth or where both codling moth and apple maggot are a problem in the same orchard.

Pyrethrum sprays have also given promising results in codling moth control, but so far their performance has not been as conclusive as that of rotenone.

After four years of field tests the results indicate that rotenone-bearing roots, such as powdered derris root, promise to be a useful addition to the apple spray program not only as primary insecticides but also when combined with other materials such as oil and lead arsenate.

NICOTINE AS A FORTIFYING AGENT FOR LEAD ARSENATE SPRAYS

Under ordinary conditions in western New York the peak of codling moth larval activity does not occur until July. At this time the de-

veloping apple fruits are normally protected by a build-up of the spray residues from at least two cover sprays. Because of an early season, the month of June 1940 was extremely favorable for codling moth activity. The young fruits, having only the protection of the first cover spray, were apparently entered at will by the newly-hatched worms. In some of the more heavily infested orchards the situation became alarming. In an attempt to meet this emergency the lead arsenate cover spray was fortified by the addition of nicotine sulfate. As a result of thoroly applying this combined spray under test conditions, all insect activity appeared to stop immediately. A few days later the weather turned cool and more normal conditions prevailed.

The following year (1941) two experimental blocks of trees were selected to determine the value of adding nicotine sulfate to a lead arsenate cover spray. In one McIntosh orchard the combination spray increased the efficiency in worm control from 94.7 per cent to 98.3 per cent. There were 53 per cent stings on the lead arsenate plat as compared with 26.4 per cent where the nicotine had been added. This orchard was well populated with the codling moth and the crop from one tree left untreated following the petal fall spray showed by actual count 1,456 worm holes in 1,225 apples.

The other McIntosh orchard selected for the test was also well infested since 93.6 per cent of the fruit on an unsprayed tree showed worm injury. The series of sprayed plats included one group of trees that received a combination cover spray of 1 pound of lead arsenate and 1 pint of nicotine sulfate in 100 gallons. The worm control on these trees was practically identical with that on a lead arsenate plat using 3 pounds of the arsenical in each 100 gallons. The fruit count showed 97.4 per cent efficiency in worm control in the former as compared with 97.7 per cent on the lead arsenate plat. There were fewer stings on the fruit from the plat where the nicotine was added.

The data from these tests appear sufficiently convincing to warrant serious consideration of this method of increasing the insecticidal efficiency of lead arsenate sprays not only by the experimental worker but also by the practical fruit grower.

SQUASH VINE BORER CONTROL

G. E. R. HERVEY, *Associate in Research* (*Entomology*)

THE most commonly used method for controlling the squash vine borer in western New York has been to split the stem lengthwise and remove the borer. This method is slow, impractical except for small plantings, and likely to be injurious to the plants. Insecticidal treatments, using materials such as lead arsenate and nicotine sulfate, have been frequently suggested but never generally accepted due to the ineffectiveness of the lead arsenate and the cost of the nicotine. Rotenone-bearing materials, which have also been tested elsewhere, usually with favorable results, have received the widest use in the experiments summarized below. This summary represents the results of five seasons' work with insecticides against this insect under field conditions.

The more promising insecticide materials were tested over the whole five-year period, while others which appeared ineffective were dropped after one or two trials. The borer population in the untreated plats ranged from 1 borer per plant in 1937 to 3.6 borers per plant in 1940. The dust treatments were applied with a hand duster of the bellows type and the sprays were applied with a knapsack sprayer. For the first and second applications when the plants were small the whole plant was treated. After the plants had started to vine only an area about 2 feet in diameter around the center of the hill was treated. All treatments were very thoro in an effort to cover the vines completely, especially near the base where most of the eggs are laid.

In western New York, the most vulnerable period in the life cycle of the insect is during the month of July when the eggs are being laid. It was during this period when the treatments were applied. Four applications were made in 1937, 1938, and 1941. Five were made in 1939 and 1940. The applications were started each year about July 1, the exact time depending on the emergence of the moths and the beginning of egg laying. The interval between applications was one week in all cases. The results of these experiments are summarized in Table 1. In 1940, each material shown in the table was tested in two separate experiments.

The borer counts were obtained about August 1 by splitting open the vines and removing the borers. In order to recover any individuals overlooked in the first count, a second examination was made about 10 days after the first. In considering the effect of these materials on the insect it would appear that rotenone dust, nicotine sulfate spray, and derris spray all will give satisfactory control. A marked reduction in the effectiveness of derris is shown when this material is reduced to 1 pound and $^1{}_2$ pound. *Syntone*, a commercial extract containing 2.8 per cent rotenone and used at 1 400 in 1940 and 1941, showed little value. Lead arsenate was largely ineffective either as a spray or a dust. The following materials which do not appear in the table have

TABLE 1.—A SUMMARY OF FIVE YEARS EXPERIMENTS AGAINST THE SQUASH VINE BORER.

MATERIAL	AMOUNT PER 100 GALLONS OF SPRAY	CONTROL EFFICIENCY, PER CENT				
		1937	1938	1939	1940	1941
1% rotenone dust	———	86.8	79.2	97.9	91.0	100.0
1% rotenone dust	———	——	——	——	94.8	——
Nicotine sulfate spray	2 quarts	76.5	81.1	93.3	88.2	91.0
Nicotine sulfate spray	———	——	——	——	67.1	——
Derris powder spray*	4 pounds	——	72.7	81.3	82.5	94.9
Derris powder spray*	———	——	——	——	91.9	——
Derris powder spray*	1 pound	——	——	——	——	62.8
Derris powder spray*	½ pound	——	——	——	——	29.9
Lead arsenate spray	4 pounds	——	48.7		——	—
25% lead arsenate dust	———	——	22.0	— —	— —	
Rotenone extract†	1 quart	——	——	——	57.0	25.8
Rotenone extract†	———	——	——	——	32.0	—

*The ground derris root used contained approximately 5 per cent rotenone.
†*Synlone*, a commercial extract containing 2.8 per cent rotenone, was used.

also been tried: *NNOR*, a commercial extract containing 1 per cent rotenone and used at 1–400 in 1941; dual-fixed nicotine dust containing 4 per cent nicotine, used twice in 1940; calcium arsenate used at the rate of 6 pounds to 100 gallons of water in 1937; and lead arsenate, 4 pounds to 100 gallons combined with bordeaux mixture 4–4–50 in 1938. The only material in this group which showed any real promise was dual-fixed nicotine dust which gave 71 and 85 per cent control.

It would appear that the rotenone dust, nicotine sulfate spray, and derris spray could be expected to give commercial control of the insect, altho to obtain such control it is very important that the treatments be thoroly applied regardless of the material used. It is also necessary that four to five applications be used and that the first treatment be timed carefully to coincide with the beginning of egg laying. The main objection to the use of the nicotine sulfate spray is its cost. Dusts are somewhat easier to apply than the sprays, a factor in favor of the rotenone dust.

It may also be noted that rotenone dust and derris spray have given very good control of the striped cucumber beetle, a point which should be considered when selecting a material for vine borer control.

DORMANT TREATMENTS FOR THE CONTROL OF CERTAIN INSECTS ON NURSERY PLANTS

F. L. GAMBRELL, *Associate in Research* (*Entomology*)

FOR a number of years experiments have been conducted for the control of such pests on ornamentals as eastern spruce gall aphid, Sitka gall aphid, and snowball aphid. Spring applications were made while the buds were in a dormant or semi-dormant condition in an effort to find satisfactory control measures for the lilac form of the oystershell scale and to improve upon those already being employed for the other insects. Altho the aim was to test dinitro sprays thoroly, mixtures of other well-known insecticides were used for comparison, including lubricating oil, coal tar oil, nicotine, and lime-sulfur. The fundamental dinitro compounds were dinitro-o-cyclohexylphenol and dinitro-o-cresol, for brevity referred to hereafter as DNOCHP, or phenol, and DNOC, or cresol.[1] These were furnished in the following forms: (1) DNOCHP and DNOC each separately dissolved in lubricating oil in the factory at the rate of about 4.8 ounces per gallon of oil; (2) each chemical compound fused with bentonite at the rate of 40 per cent toxicant to 60 per cent bentonite and the mixture powdered; and (3) the sodium salt of DNOC in paste form either with so-called "penetrants" (Elgetol)[2] or without penetrants (Stantol).[2] The powders were used both in oil emulsions and as water suspensions. Also Elgetol, altho used mostly in water solution, was tested in oil emulsion.

Field experience has demonstrated that the needles of most species of conifers are rather susceptible to all dinitro insecticides in oil, whereas such plants as lilac, willow, and snowball (*Viburnum* spp.) appear to be quite tolerant. There is some variation in susceptibility to injury between different species of conifers. For the past several years Elgetol has been tested at 1 gallon (equivalent to 27.5 ounces of DNOC) and at ½ gallon (equivalent to 13.8 ounces of DNOC) concentrations. All concentrations mentioned in this discussion are per 100 gallons of spray mixture.

Both concentrations of Elgetol injured the needles of a number of species of conifers but did not affect those of Mugho and white pine. During 1941 sprays containing 1 gallon of Stantol (equivalent to 42 ounces of DNOC) did not show indications of injury on Norway and white spruce and on Jeffrey, Mugho, red, Scotch, and white pine foliage. Field tests during 1940 and 1941 indicate that sprays with dry powders containing either DNOCHP or DNOC in the form of water suspensions at the rate of 4 ounces of toxicant per 100 gallons are non-injurious to several species of evergreens and are also effective in the control of certain insect pests.

Oystershell scale.—Repeated experiments indicate that the lilac

[1]Furnished by the Dow Chemical Company, Midland, Mich.
[2]Furnished by Standard Agricultural Chemicals, Inc., Hoboken, N. J.

form of the oystershell scale, *Lepidosaphes ulmi* L., is more difficult to control with dormant treatments than is the form that occurs on apples—so much so that the treatment normally recommended for control on apples has not proved satisfactory on lilac and willow. For this reason it has been necessary to use higher concentrations of dinitro sprays in an effort to obtain control. The results obtained in 1940 and 1941 (Table 1) indicate that a dormant spray containing 3 to 3.75 gallons of petroleum oil (108° viscosity) and 18.8 to 24 ounces of toxicant in the form of either DNOC or DNOCHP will afford satisfactory control. Elgetol, 2 gallons, (equivalent to 55 ounces of DNOC) in water gave fair control, and excellent control was secured with 2 gallons in 4 gallons of lubricating oil. Sufficient information has not been obtained with water suspension sprays containing powders either of DNOCHP or of DNOC to indicate their utility on this insect. As regards other water-soluble compounds, in 1940 a tank mixture containing 48 ounces of DNOC powder, together with 39 ounces of potassium hydroxide in water, showed promising results. Thus far no serious injury to lilacs has been observed with any of the mixtures at the concentrations indicated, provided application was made prior to the separation of the bud scales. Nevertheless it is suggested that dinitro sprays, as a group, be used with caution for the control of this pest on lilac until their safety and utility have been more thoroly determined.

Spruce gall aphid.—In experiments conducted for several years for the control of the eastern spruce gall aphid, *Adelges abietis* Kalt., sprays containing lubricating oil with dinitro compounds and also Elgetol without oil and Stantol have been tested in comparison either with lime-sulfur or with nicotine sulfate and soap. In general, results have been satisfactory insofar as control is concerned, but all of the above types of dinitro sprays with the exception of powder suspensions and Stantol have caused noticeable foliage injury on both Norway and Colorado blue spruces (Table 1).

Snowball aphid.—During 1939 both DNOCHP and DNOC were tested at the rate of 1.6 and 18.8 ounces of toxicant, with ¼ and 3 gallons of lubricating oil, respectively, for the control of the egg stage of the snowball aphid, *Aphis viburnicola* Gillette, with satisfactory results.[3] Experiments with the above types of dormant materials were continued in 1940 and 1941, together with dinitro powders as water suspensions, coal tar oil, lubricating oil alone, lime-sulfur alone and with nicotine sulfate, and also soap and nicotine. Lubricating oil proved unsatisfactory in controlling this pest. The results with coal tar oil have been somewhat variable, whereas oil-soluble, water-soluble, and water-suspension sprays containing dinitro powders (DNOCHP and DNOC) have afforded satisfactory control.

Present information (Table 1) indicates that a dormant spray containing approximately 4.7 ounces of actual toxicant (either DNOCHP

[3]Gambrell, F. L. "Snowball" bushes are sometimes deformed by aphids. *Farm Research*, **7**, *No. 1, 15. 1941.*

TABLE 1.—RESULTS OF DORMANT TREATMENTS ON SNOWBALL APHID, SPRUCE GALL APHID, AND OYSTERSHELL SCALE*.

MATERIALS	LUBRICATING OIL OR OTHER LIQUIDS, GALLONS	DNOCHP, DNOC OR EQUIVALENT, OUNCES	PERCENTAGE REDUCTION OF INFESTATION		
			Snowball aphid	Spruce gall aphid	Oystershell scale
Dormant Stage					
Lubricating oil	0.75	0	35.1	——	——
Lubricating oil	5.00	0	——	——	2.7
DNOCHP+lubricating oil†	0.20	1.2	——	99.4	——
DNOCHP+lubricating oil	0.25	1.6	99.4	——	——
DNOCHP+lubricating oil	0.76	4.7	99.9	——	——
DNOCHP+lubricating oil	3.00	18.8	——	——	95.3
DNOC +lubricating oil†	0.20	1.2	——	99.2	——
DNOC +lubricating oil	0.25	1.6	98.1	——	——
DNOC +lubricating oil	0.76	4.7	100.0	——	——
DNOC +lubricating oil	3.00	18.8	——	——	96.4
DNOCHP powder	0	1.6	97.5	——	——
DNOCHP powder	0	4.0	85.4	97.9	——
DNOC powder	0	1.6	87.5	——	——
DNOC powder	0	4.0	99.9	99.9	——
Elgetol, 1/15 gallon‡	0	1.8	89.6	——	——
Elgetol, ¼ gallon	0	6.9	96.4	97.8	——
Elgetol, 1 gallon	0	27.5	100.0	100.0	——
Elgetol, 2 gallons	0	55.0	——	——	88.4
Elgetol, 2 gallons+lubricating oil	4.0	55.0	——	——	99.9
Stantol, 1 gallon§	0	42.0	99.9	100.0	——
Stantol, 2 gallons	0	84.0	——	——	98.4
Coal tar oil	2.4	0	100.0	——	——
Coal tar oil	4.7	0	——	——	0 ‖
Lime-sulfur	2.5	0	——	99.8	——
Lime-sulfur	12.5	0	65.9	——	0 ‖
Lime-sulfur+nicotine sulfate, 1 quart	12.5	0	91.9	——	——
Green-tip Stage					
Soap+nicotine sulfate, 1 quart	1.0	0	90.4	99.9	——

*All tests made in 1941 except where otherwise specified. All concentrations for 100 gallons of spray mixture.

†All DNOCHP and DNOC furnished by Dow Chemical Company, Midland, Mich.

‡Elgetol is a commercial preparation containing sodium dinitro-o-cresylate, equivalent to 27.5 ounces of DNOC, and other materials which the manufacturers call "penetrants". Furnished by Standard Agricultural Chemicals, Inc., Hoboken, N. J.

§Stantol is a commercial preparation containing sodium dinitro-o-cresylate, equivalent to 42 ounces of DNOC. Furnished by Standard Agricultural Chemicals, Inc., Hoboken, N. J.

‖Tests made in 1940.

or DNOC) in the form of either a powder in a water suspension or dissolved in 1 gallon of lubricating oil, or ¼ gallon of Elgetol is both safe and effective. Some evidence has also been obtained that suggests that a dosage of 1.6 ounces of DNOCHP or DNOC dissolved in ¼ gallon of lubricating oil or of 1.8 ounces of DNOC in water-soluble

form (Elgetol) will also afford good control. However, these latter concentrations are not generally recommended at the present time. The nicotine-soap spray, diluted at the rate of 1 quart of nicotine sulfate and 1 gallon of potash fish-oil soap, has also given fair control, but requires careful timing with regard to the hatching of eggs and mild weather for best results.

RELATION OF OIL DEPOSITS TO THE CONTROL OF THE ORIENTAL FRUIT MOTH ON QUINCES

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SINCE the appearance of the oriental fruit moth in New York, quince plantings have been severely attacked by this pest. Poorly sprayed and abandoned orchards have usually experienced 100 per cent infestation of fruit. Biological control, which has been notably successful against this insect in peach plantings, has been ineffective on quinces due to a difference in larval feeding habits. It has therefore been necessary to rely entirely upon insecticides for control treatments. Sprays containing arsenate of lead or summer oil and nicotine have been recommended for some time, altho problems associated with the removal of lead arsenate residues have favored the greater use of oil-nicotine sprays. Unfortunately, such sprays have not always been uniformly successful under practical conditions. In 1941, therefore, an investigation was begun to determine possible causes of the irregular results frequently obtained from the use of oil-nicotine sprays on quinces.

For this investigation a quince orchard was selected which was known to have a heavy oriental fruit moth infestation. Following the application of a calyx spray and two cover sprays of lead arsenate, oil spray treatments were begun and continued at two-week intervals for the remainder of the season. All oil sprays contained nicotine in the form of Black Leaf 40 which was used at the rate of 1 pint per 100 gallons. Orthol K, a commercially prepared summer oil emulsion containing approximately 75 per cent oil and mixed at the rate of 4 quarts per 100 gallons of water, was used in comparison with a commercially available oil of high paraffinic character derived by a solvent process and having a viscosity of 79 seconds (Saybolt 100° F). This oil was applied at strengths of 1, 2, and 3 quarts per 100 gallons and in each case was tank emulsified with blood albumin at the rate of 2 ounces per 100 gallons. The degree of insect control obtained with these various spray mixtures is indicated in Table 1.

To determine the relation of oil deposits to insect control, the oil

TABLE 1.—THE EFFECTIVENESS OF OIL SPRAYS CONTAINING NICOTINE AGAINST THE ORIENTAL FRUIT MOTH ON QUINCES, 1941.*

MATERIAL*	QUARTS USED PER 100 GALLONS	PERCENTAGE CONTROL EFFICIENCY
Tank-mixed oil	1	75.4
Tank-mixed oil	2	83.3
Tank-mixed oil	3	86.6
Orthol K	4	86.1

*All sprays contained 1 pint of Black Leaf 40 per 100 gallons.

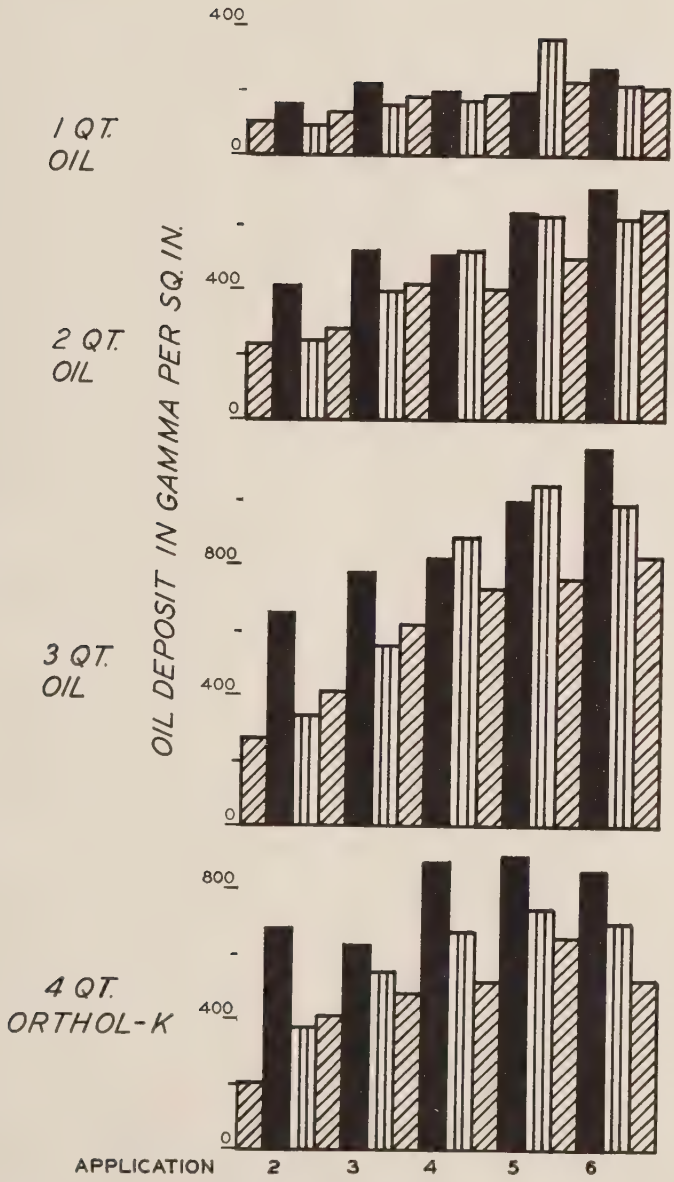

FIG. 1.—A COMPARISON OF THE OIL DEPOSITS PRODUCED ON QUINCE LEAVES BY SUCCESSIONS OF OIL SPRAYS.

The oil deposits were measured immediately after each spray application (solid black columns), 7 days later (vertically lined columns), and 14 days later (diagonally lined columns). The latter measurement samples were taken immediately before the next scheduled spray application. The measurement unit "gamma", used to express the amount of oil deposited, equals one-millionth of a gram.

was extracted from leaf samples collected (1) immediately after each spray application, (2) 7 days later, and (3) 14 days later, just before the next spray was applied. Each sample consisted of 100 disks, each 7/8 inch in diameter, cut from leaves collected at random from each sprayed plat. The oil deposit data obtained by this method are shown graphically in Fig. 1. It will be observed that the oil residue deposits are not greatly dissipated during the intervals between spray treatments and therefore that a cumulative increase in the total oil deposited occurs as more applications are made. According to Chapman, *et al.*,[1] such residues are greatly in excess of the oil deposits necessary for adequate insect control by any single spray application.

The results thus far obtained indicate that on quinces most oriental fruit moth control occurs immediately following each spray application and that residual oil deposits are probably of lesser importance. This would indicate that where difficulty is experienced in controlling the pest more effective results might be obtained by shortening the interval between applications using the same or even smaller amounts of oil.

[1]Chapman, P. J., Pearce, G. W., and Avens, A. W. The use of petroleum oils as insecticides. V. The toxicity of summer type oils to eggs of the oriental fruit moth and codling moth. *Jour. Econ. Ent.*, **35,** *1942*.

INSECTICIDAL CONTROL OF THE RASPBERRY CANE BORER

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THE work of the raspberry cane borer, *Oberea bimaculata* Oliv., may be distinguished from that of other insects found in raspberry and blackberry plantings by characteristic injuries produced during adult feeding, oviposition, and larval burrowing. The adults attack both the leaves and the outer green tissue of the new canes and laterals. Greater damage results from oviposition punctures made by adult females. At this time two encircling girdles are made near the tip of the cane which restrict or stop the flow of sap and usually cause the tip to wilt and drop off. The most severe injury is caused by larval burrowing. A cane or lateral thru which a larva has tunneled is completely destroyed. During this proces the pith is usually consumed and the surface of the cane may be riddled with small holes. Up to the present the standard method for controlling the raspberry cane borer has been the removal of cane tips injured by oviposition punctures and the destruction of canes and stubs containing the larvae. As a result of preliminary tests in 1939 and more intensive experiments in 1941, the use of insecticides may now, for perhaps the first time, be considered as having a definite place in the control of this pest.

The results of a representative 1941 test in western New York are summarized in Table 1. The first treatments were made on June 10 while many blossom buds of Latham raspberries were still tightly closed, altho some borer adults had emerged and injury was already present. The second treatments were applied on June 26, when many Latham fruits were well filled out. All data shown in the table are

TABLE 1.—RESULTS FROM A REPRESENTATIVE SERIES OF INSECTICIDE TESTS AGAINST THE RASPBERRY CANE BORER, 1941.

MATERIAL*	NUMBER OF APPLICATIONS	TOTAL NUMBER OF CANES COUNTED	PERCENTAGE INJURY	PERCENTAGE CONTROL EFFICIENCY
Derris spray	1	1,605	5.6	90 8
Derris spray	2	1,868	7.8	87.2
Berako spray	2	1,139	12.7	79.2
Black Leaf 155 spray	1	1,510	27.2	55.3
Black Leaf 155 spray	2	1,206	29.8	51.1
One per cent rotenone dust	1	329	16.7	72.6
One per cent rotenone dust	2	638	12.9	78.8
Untreated	–	1,720	60.9	

*The spray mixtures were prepared as follows: The derris sprays all contained 5 pounds of ground derris root (analyzing approximately 4.8 per cent rotenone) and ½ pound of soybean meal per 100 gallons. Berako, a commercial extract containing 2½ per cent rotenone, was used at the rate of 1 pint per 100 gallons. Black Leaf 155 was used at the rate of 3 pounds per 100 gallons with ½ pound of soybean meal.

based on records taken between June 10 and July 2. The sprays were applied with power equipment, while the dust treatments were made with rotary hand dusters.

From the data presented it may be concluded that derris sprays gave the best control, altho two applications were apparently no better than one. Dust treatments with rotenone were somewhat less effective than derris or Berako sprays. It was also indicated that in some seasons a single treatment for the raspberry cane borer may give some protection against the red-necked cane borer, *Agrilus ruficollis* Fabr., and the bronze cane borer, *Agrilus rubicola* Abeille. Because of seasonal variations and differences in the varietal development of raspberries, the timing of insecticide treatments for raspberry cane borer control should be determined by the appearance of injury and the degree of plant development. Insecticide treatments are probably most effective if applied directly after the first blossoms open. Thoro applications, covering the tips of the canes and laterals of all plants from the lowest to the highest, are necessary to insure adequate control. Altho some protection can be obtained by the removal of infested plant parts, the use of insecticides appears to offer a more promising method of attack.

PEA APHIDS AS A FACTOR IN GROWING PEAS ON LONG ISLAND

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PEAS on Long Island are raised for the local market from such varieties as Gradus and Thomas Laxton. Within recent years this crop has for several reasons been considered unprofitable by many growers. One reason has been the loss caused by pea aphid infestations and pea mosaic, a virus disease which is transmitted chiefly by the pea aphid. During the past three seasons the presence of pea aphids and foliage symptoms of pea mosaic have been closely observed in relation to the development of control measures for reducing the crop injury from such causes.

The data gathered tend to show that pea seedlings were subject to infestation by aphids as soon as they emerged above ground (late April). Aphid activity was very limited during the cool weather conditions at the time of preblossom growth. Plant infestation remained below 10 per cent and the aphid population did not exceed an average of more than one aphid per plant sample until late May. Likewise mosaic infection, as observed, was restricted to isolated instances in the field with an insignificant increase during this period.

The sudden rise in aphid infestation and mosaic infection to menacing proportions occurred, when present, during a period of much warmer weather than is commonly prevalent during the greater part of May on Long Island. Such spells did not occur until the latter part of May. At such a time the crop was in bloom and within three weeks of harvest.

Data from plots which received protective applications of a 1 per cent rotenone dust or a standard rotenone spray (4 pounds ground derris root, 4 to 5 per cent rotenone, per 100 gallons plus spreader) indicated that one or two timely treatments made during the latter part of May, from two to four weeks before harvest, were often beneficial as measured in terms of crop yield.

A SHORTENED, INTENSIVE SUMMER SPRAY PROGRAM FOR APPLES IN EASTERN NEW YORK[1]

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A need has arisen in eastern New York for a summer spray program for apples which will effectively control the codling moth and apple maggot early in the season and with a reasonable expenditure of time, money, and materials. During 1941 an experimental spray program was tested which may now be seriously considered by interested persons even tho it may not be advisable for general use by all eastern New York apple growers. This program is designed to control the codling moth and apple maggot without spray treatments during late July and in August against the second brood of the codling moth. These late treatments are undesirable because of the costs involved, the objectionable visible residues resulting when certain so-called arsenical substitutes are used, the objectionable "oily" finish on fruits sprayed late in the season with summer oils, and the above-tolerance residues remaining from the use of arsenicals and similar insecticides. Similar programs were tested in years prior to 1941, altho the data obtained are not applicable to the present discussion because of changes made in 1940 in the legal tolerances for lead and arsenic.

The experimental orchard used in 1941 was located near Poughkeepsie, N. Y., and contained 230 mature apple trees, mostly McIntosh. For several years past this planting had supported a heavy codling moth population as, for example, in 1940 when 45 to 50 per cent of the apples were estimated to have been damaged by this insect. In 1941, 2,312 moths were captured in 10 bait traps operated during the period of spring brood flight. The orchard was separated from other apple plantings by at least 300 feet, thereby reducing the possibility of inward moth migrations. The orchard was given the regular fungicide and insecticide treatments before it was made available for experimental purposes. In an attempt to cover the trees as thoroly as possible, approximately 1 gallon of spray was used per application for each bushel of fruit the trees were capable of bearing. The trees were sprayed from the ground, both inside and outside, and the tops of the larger trees were treated from the top of the spray tank.

The following is an outline of the experimental spray schedule used in 1941, the materials enumerated being used with water to make 100 gallons of spray:

Curculio spray, May 16, 1941:

Lead arsenate	3 lbs.
Spray lime	3 lbs.

[1]This experimental work was conducted as a cooperative project between this Station and the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine.

Sulfur	4 lbs.
Skimmilk powder	¼ lb.
First cover spray, May 28, 1941:	
Lead arsenate	3 lbs.
Spray lime	3 lbs.
Nicotine sulfate	¾ pt.
Skimmilk powder	¼ lb.
Second cover spray, June 9–10, 1941:	
Lead arsenate	3 lbs.
Spray lime	3 lbs.
Nicotine sulfate	½ pt.
Skimmilk powder	¼ lb.
Third cover spray, June 18–19, 1941:	
Fixed nicotine (Black Leaf 155 Concentrate, 14% nicotine)	1½ lbs.
Summer oil	2 qts.
Fourth cover spray, July 1, 1941:	
Lead arsenate	3 lbs.
Spray lime	3 lbs.
Skimmilk powder	¼ lb.

In formulating the program outlined above it was recognized that some insecticides effective against the codling moth are of little or no value against the apple maggot. Since the periods of attack by these two insect pests overlap, it was important to use a program which permitted the combining of insecticides, at least one of which was effective against each pest. Lead arsenate and nicotine in some form were chosen as the principal insecticides to be used. Four cover sprays were applied. In the first two cover sprays the lead arsenate was fortified with nicotine sulfate in order to kill as many codling moths as soon as possible after emergence, thereby preventing oviposition, also to kill a maximum number of young larvae before they could enter the fruits. The value of the added nicotine was reflected in the sharply decreased numbers of codling moths captured in bait traps after each of these two sprays was applied. In less severe infestations the use of nicotine could be limited to one of these sprays, applied in the period of greatest moth abundance. A so-called fixed nicotine was used in the third cover spray, directed primarily against the codling moth. The fourth cover spray, applied when greatest protection was needed against the apple maggot, contained lead arsenate.

This spray program produced commercial control of the codling moth in 1941 as indicated by the following harvest data obtained by an examination of the picked and dropped fruits of 20 McIntosh trees chosen at random thruout the planting:

Percentage of clean apples	94.54
Percentage of "stung" apples	3.62
Percentage of wormy apples	2.14

The arsenious oxide and metallic lead residues on the harvested fruit were 0.022 and 0.045 grain per pound, respectively, both of which were below the corresponding legal tolerances of 0.025 and 0.050 grain per pound, respectively.

No data on apple maggot control are presented since this pest had not caused commercial damage in the experimental orchard in recent years and since there was no evidence of maggot injury to the 1941 crop. However, the results obtained from similar tests in other orchards indicate that the spray program as outlined will keep light infestations of the apple maggot in check. When higher infestations are present, a fifth cover spray might be made. Such an application was made on July 14, 1941, to a few trees in the orchard described above, using 3 pounds of calcium arsenate per 100 gallons of spray. Here, the harvest residues were 0.023 grain of arsenious oxide and 0.044 grain of metallic lead per pound of fruit. Similar results could be expected by the use of a 20 per cent calcium arsenate dust. In other tests where a fifth cover spray was used containing 3 pounds of lead arsenate per 100 gallons of water, or where a 20 per cent lead arsenate dust was substituted, the harvest residues were in excess of the legal tolerances.

Apple growers likely to be interested in the type of program outlined above should bear in mind that the use of such a schedule might not always produce a degree of control comparable to that described. Any compromise with thoroness and completeness of spraying or with accurate timing will invite disaster. During the first season such a program is attempted, the grower should maintain the closest watch of his plantings during early August for the possible appearance of destructive numbers of second-brood codling moth larvae. In such an eventuality the prompt application of a nicotine spray should prove profitable. In years when the codling moth is unusually abundant the greatest vigilance will be required thruout the season. It should be observed that the dates for applying the cover sprays will vary from season to season. In a more normal year the dates of application would probably be later than those shown above for the experimental orchard in 1941.

USE OF DUSTS FOR EUROPEAN CORN BORER CONTROL[1]

L. A. CARRUTH, *Associate in Research* (*Entomology*)

AS a result of the increased importance of the European corn borer in New York during the past few seasons, the development of more effective methods for controlling this pest, particularly in market sweet corn, has received serious attention. This insect is now generally established over the greater part of New York State and most sections where market sweet corn is grown on a commercial scale have experienced borer injury of greater or lesser importance at one time or another during the past few seasons. It appears that at least a small residual borer population is continuously present in most areas and that when favorable conditions for borer development occur serious outbreaks may be expected. An indication of the extent and degree of injury found in 1941 is shown in Table 1.

TABLE 1.—AN INDICATION OF THE EXTENT AND DEGREE OF EUROPEAN CORN BORER INJURY TO SWEET CORN IN 1941.*

LOCATION OF TEST (COUNTY)	PERCENTAGE OF FULL-SIZED EARS INFESTED
Columbia	44
Rensselaer	49
Albany	29
Schenectady	28
Onondaga	33
Monroe	51
Niagara	73

*Data taken from untreated sections of selected test fields. These records were taken from fields maturing during peak periods of borer abundance and therefore do not represent seasonal averages. The effects of conditions unfavorable to borer development are reflected in the lower infestations found in eastern New York counties in 1941. Near-drought conditions during the critical period of borer development in May and June are believed to be a principal factor. Had more normal rainfall occurred, higher infestations would probably have resulted.

Of the various methods investigated for controlling the European corn borer, the use of insecticides, particularly in the form of dusts, appears to be the most satisfactory means of control now available. Four successive applications at 5-day intervals are usually required for effective control of the newly hatched and migrating larvae. Altho spray treatments have been found effective when properly applied, certain practical difficulties, particularly the transportation of large quantities of water in a cornfield, have prevented the general adoption of this form of control. Of the various dust materials which have been used, dual-fixed nicotine dust and 1 per cent rotenone dust have been the most consistently effective and have not differed

[1]A portion of the experimental work upon which this discussion is based was made possible by the helpful cooperation of the Tobacco By-Products and Chemical Corporation. The cooperation of the Cooperative G. L. F. Soil Building Service, Inc., and the R. T. Vanderbilt Company, Inc., is also acknowledged.

FIG. 1.—RESULTS OBTAINED FROM DUSTING SWEET CORN FOR BORER CONTROL IN NIAGARA COUNTY, N. Y., IN 1941.

The piles of corn from left to right represent the proportion of (1) dusted, clean ears; (2) dusted, infested ears; (3) untreated, clean ears; and (4) untreated, infested ears. (Photo by G. E. R. Hervey.)

FIG. 2.—TRACTOR DUSTER OUTFIT USED IN COLUMBIA COUNTY IN 1941.

Four rows were dusted in one operation, using three nozzles per row as indicated. Five acres were dusted per hour. The corn, an early hybrid variety, is shown at the time of the final insecticide treatment. No plant injury from the low axle clearance was observed when dusts were applied when the plants were dry and flexible.

greatly in their performance under New York conditions.[2] An indication of the degree of control which may be obtained from the use of dusts is shown in Fig. 1 and also in Table 2, where the results from two tests conducted in 1941 are briefly summarized. The dusters used for these tests are shown in Figs. 2 and 3.

Because of the variations in borer infestations which occur during the course of a single season and between different seasons and localities, it is important to know when dusts are or are not required. Due to local differences in borer behavior, dust treatments are usually begun early in June in eastern New York but nearly a month later in central and western New York. A careful examination of local conditions is necessary to determine finally when and if treatments are advisable during a particular season. The intensity of early infestations, the extent and period of maturity of sweet corn plantings, the possible presence of weather conditions unfavorable for borer development, and the probable price of the harvested crop are a few of the factors which should be considered. When the crop is sufficiently valuable it may be desirable to begin a schedule of treatments as a form of insurance. Later applications can then be omitted if for any reason the expected infestations fail to develop. When infestations are present, however, a full schedule of four applications is necessary for effective results.

FIG. 3.—WHEELBARROW TRACTION DUSTER USED IN MONROE AND NASSAU COUNTIES IN 1941.

An acre was dusted in about 1½ hours without an impractical physical effort. Because of its relatively low cost and adaptability for dusting operations on other crops than corn, a duster of this type should be of value to growers having a succession of relatively small sweet corn plantings and for whom a larger dusting outfit would be financially impossible.

[2]An additional recent discussion of the use of dusts and sprays for European corn borer control is presented by Neely Turner in Circular 147 of the Connecticut Agricultural Experiment Station, published in October 1941.

TABLE 2.—THE EFFECT OF INSECTICIDAL DUSTS UPON EUROPEAN CORN BORER CONTROL AS SHOWN BY DATA FROM TWO TESTS CONDUCTED IN 1941.

CLASSIFICATION OF EARS	PERCENTAGE OF FULL-SIZED EARS		
	Untreated	Dual-fixed nicotine dust	1 per cent rotenone dust
Tractor Duster Test, Columbia County			
U. S. No. 1, borer-free	56.4	90.3	89.2
Infested, but salable*	18.0	3.2	8.1
Infested, not salable	25.6	6.5	2.7
Wheelbarrow Duster Test, Monroe County			
U. S. No. 1, borer-free	48.6	86.5	81.6
Infested, but salable	14.3	8.1	5.3
Infested, not salable	37.1	5.4	13.2

*Ears were considered "infested, but salable" when all traces of infestations could be removed by breaking off a portion of the shank at the base and/or not over 1½ inches of the ear tip. The New York pure-food law prohibits the sale of "contaminated" foods, which include sweet corn ears infested with the European corn borer or other insects. A ruling by the New York Commissioner of Agriculture and Markets, dated August 12, 1941, states in part that "Only sweet corn offered as U. S. Fancy Grade or U. S. No. 1 Grade will be acceptable in New York State markets . . ." Neither of these grades allow insect damage extending more than 1½ inches from the tip of the ear, altho a tolerance of 10 per cent is allowed for ears falling below this standard.

TABLE 3.—THE EFFECTS OF YIELD PER ACRE AND SELLING PRICE OF MARKET SWEET CORN UPON TOTAL INCOME RECEIVED AND PROBABLE GAINS TO BE DERIVED FROM DUSTING FOR EUROPEAN CORN BORER CONTROL.

TREATMENT	SELLING PRICE PER 100 U. S. NO. 1 EARS*	ASSUMED YIELD OF FULL-SIZED EARS PER ACRE		
		8,000	10,000	12,000
Dusted	$3.00	$215	$268	$322
Not dusted	3.00	142	178	213
Av. net gain	——	*45*	*63*	*81*
Dusted	2.00	144	180	216
Not dusted	2.00	97	121	145
Av. net gain	——	*19*	*31*	*43*
Dusted	1.50	108	135	162
Not dusted	1.50	73	90	109
Av. net gain	——	*7*	*16*	*25*
Dusted	1.00	72	90	108
Not dusted	1.00	48	61	73
Av. net gain	——	*−5*	*1*	*7*

*Where U. S. No. 1 ears had calculated values of $3.00, $2.00, $1.50, and $1.00 per 100 ears, the "infested but salable" ears were assumed to have had values of $1.25, $1.00, $0.75 and $0.50 per 100 ears, respectively. These latter returns are included in the total estimated income per acre.

Under conditions of heavy borer infestation the practicability of insecticide treatments is greatly affected by the expected yield of full-sized ears and the probable market value of the crop. For purposes of illustrating the influence of price and yield on profits to be expected from dusting, Table 3 has been projected from the data shown in Table 2. For brevity the values for the dusted ears represent an average of the results obtained in the two experiments from dual-fixed nicotine dust and 1 per cent rotenone dust, both of which have usually given comparable borer control in tests under New York conditions. It is assumed in Table 3 that a total of four dust applications are made, each at the rate of 50 pounds per acre. For illustrative purposes only, an average cost of $24.00 per acre for insecticides, plus an additional $4.00 for labor, depreciation, and other expenses, is assumed. Actual costs will vary with the price of insecticides and labor. The figures for "net gain" were obtained by subtracting the assumed cost of treatment plus the returns from untreated ears from the total amount received for the treated ears.

From a study of Table 3 and its implications it would appear that when serious European corn borer infestations are present the use of insecticide dust treatments is definitely profitable if a price of $1.50 or more per 100 U. S. No. 1 ears can be obtained. Such treatments are scarcely practical even at this price unless a good yield (10,000 ears or more per acre) is expected. It should be observed that under New York conditions, a gross income of $100.00 an acre for market sweet corn is usually considered the minimum adequate remuneration for the expense involved in growing sweet corn. Any added cost for insecticide treatments must be paid from an increased income above this level. When borer infestations occur during periods of good yields and high prices (usually found early in the season) insecticide dust treatments should prove particularly profitable.

A NEW BASIS FOR SELECTING PETROLEUM OILS FOR ORCHARD SPRAYS

P. J. CHAPMAN, *Chief in Research* (*Entomology*), G. W. PEARCE, *Associate in Research* (*Chemistry*), AND A. W. AVENS, *Assistant in Research* (*Chemistry*)

PETROLEUM oils are used extensively in insecticidal preparations either alone or combined with other toxicants. For variety of uses, petroleum products probably exceed all other materials employed today in insect control. A light oil resembling kerosene is the base product in household and cattle "fly sprays", while various heavier fractions are used in dormant and summer sprays applied to fruit, vegetable, and ornamental plants, in dusts and sprays as adhesives, in grasshopper poison baits as conditioners, and in many other ways.

A general investigation of the use of petroleum oils as insecticides has been undertaken at this Station. Thus far, attention has been given to water-borne oil sprays and their use against apple and other fruit insects. Such sprays are applied in the form of emulsions in which the oil is maintained in minute droplets suspended in the water thru the aid of agitation and an emulsifier. The subject of emulsifiers is discussed elsewhere in this publication (page 15).

The oils now being used in sprays applied to apple and other deciduous fruit trees in the dormant or semi-dormant periods are light-grade oils of the general lubricating fraction which are used for many purposes other than as spray oils. They have an approximate viscosity of 100 seconds Saybolt at 100° F. In general, these oils have received no special treatment in the refining process. No serious effort has ever been made to find the ideal dormant spray oil measured both by insecticidal performance and safeness to the tree, probably for the reason that the oils used have seemed to give fairly satisfactory results, altho plant sensitivity to oil sprays has restricted their use.

The writers have approached the task of finding a better type product for this purpose by studying the relation of the chemical composition of the oil to its efficiency. Petroleum oils are known to be highly complex, chemically, and further, their composition varies greatly according to the geographic origin of the oil and its treatment in refining. In 1941, 40 different oils were compared in orchard tests to determine their efficiency in controlling the fruit tree leafroller. The principal producing areas of the United States were represented in these test oils and they included straight run, blended, acid-treated, and solvent-processed oils. All were of essentially the same viscosity, ranging from 90 to 125 seconds. A detailed report of this investigation is being presented elsewhere,[1] but some of the significant data obtained are given in Table 1.

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[1]Pearce, G. W., Chapman, P. J., and Avens, A. W. The use of petroleum oils as insecticides: IV. The efficiency of dormant type oils in relation to their composition. *Jour. Econ. Ent.*, **35**. *1942*.

TABLE 1.—THE RELATION OF OIL COMPOSITION TO FRUIT TREE LEAF ROLLER CONTROL, 1941.

OIL NO.	OIL PROPERTIES		PERCENTAGE OIL IN SPRAY*	MILLIGRAMS OF OIL DEPOSITED PER SQ. IN. OF BARK	PERCENTAGE LEAFROLLER EGGS KILLED
	Gravity (A. P. I.)	Viscosity index (A. S. T. M.)			
I2	36.0	117	2.0	0.90	99.8
I1	31.6	90	2.0	0.93	89.7
A1	27.8	63	2.0	1.20	63.2
A1	27.8	63	2.5	1.33	81.9
A1	27.8	63	3.0	1.60	97.7
A2	25.5	25	2.0	0.86	54.4
A2	25.5	25	3.0	1.41	76.7
A2	25.5	25	4.0	2.16	97.7
D1	21.8	−4	2.0	0.91	32.1
D1	21.8	−4	2.0	1.05	52.7
D1	21.8	−4	3.0	1.81	62.8
D1	21.8	−4	4.0	2.86	93.5
D1	21.8	−4	5.0	3.00	99.2

*All test sprays were "tank-mixed" using blood albumin, 2 ounces per 100 gallons of spray.

From these data it is evident that oils of the same viscosity may differ radically in insecticidal efficiency. A correlation is shown between efficiency and the properties of gravity and the viscosity index, which, along with other physical tests, are indicative of the general characteristics of an oil. The paraffinic character of an oil is known to increase with an increase in gravity and the viscosity index values. Thus, the data show a high correlation between efficiency and the "paraffinicity" of an oil, the higher the paraffinic character the more efficient the oil. It is of passing interest to note that the kinds of oil used in most commercially prepared oil sprays at present are typified by Oils A2 and D1 of Table 1. With such preparations it may be necessary to use as high a concentration as 8 per cent oil to kill 95 to 100 per cent leaf roller eggs because the emulsifiers frequently used in these products often give light deposits of oil on the plant.

Because of the obvious immediate need of some standard for dormant spray oils other than viscosity, the writers give some additional tentative specifications in Table 2.

Present indications are that these standards will be raised to obtain greater efficiency and safeness. In regard to safeness, the data in Table 1 do suggest this point, namely, that if we assume that all oils are equally toxic to fruit trees, those that can be used at a low concentration because of high insecticidal efficiency (oils I2 and I1, for example) should be less harmful than those which must be used at higher concentrations because of lower insect killing capacities.

Preliminary data obtained on the so-called summer oils (60 to 70 seconds viscosity) in the control of the codling moth and the oriental

TABLE 2.—TENTATIVE SPECIFICATIONS FOR A DORMANT TYPE SPRAY OIL.*

Viscosity (Saybolt, at 100° F)	90 to 120 seconds
Viscosity index (Kinematic)†	65 (minimum)
Gravity (A. P. I. degrees)	28 (minimum)
Pour point	Not greater than 30° F
Homogeniety	A relatively narrow boiling distillate portion of petroleum

*The following methods of testing spray oils are to be used: *Viscosity:* Kinematic, A. S. T. M. Designation: D 445–39T. *Conversion to Saybolt Universal Viscosity*, A. S. T. M. Designation: D446–39. *Kinematic Viscosity Index:* A. S. T. M. Designation: D567–40T. *A. P. I. Gravity:* A. S. T. M. Designation: D287–39. *Pour Point:* A. S. T. M. Designation: D97–39.

†Viscosity index is not ordinarily applied to oils of this viscosity range, but since a high correlation between insecticidal efficiency and viscosity index has been obtained it is considered justifiable to apply it to dormant spray oils.

fruit moth (in quinces) show a similar relationship between efficiency and chemical composition of the oil as noted with dormant oils. At present the preferred type of summer oil indicated is one having a Saybolt viscosity at 100° F of between 60 and 70 seconds, an unsulfonated residue above 90 per cent and of a distinctly paraffinic nature.

RECENT INVESTIGATIONS ON CHERRY FRUITFLIES[1]

D. W. HAMILTON, *Assistant Entomologist, United States Department of Agriculture, Bureau of Entomology and Plant Quarantine*

PRIOR to 1937 the prevailing method for controlling cherry fruitflies (*Rhagoletis cingulata* (Loew) and *R. fausta* (O.S.)) in the Hudson Valley was the application of two lead arsenate cover sprays during June. Altho adequate control was obtained, excessive residues of lead and arsenic occurred on the fruit at harvest. Consequently, a lead arsenate spray program, altho suitable for canning cherries which could be washed before processing, was not satisfactory for use on cherries that were to be sold as fresh fruit. From 1937 thru 1940 field investigations were conducted with insecticides, both as sprays and dusts, which were believed to have possibilities as lead arsenate substitutes for cherry fruitfly control. The materials tested were rotenone-bearing materials (the ground roots of both derris and cube), phenothiazine, basic zinc arsenate, and xanthone. During these investigations, a total of 17 test blocks were used. Each block represented either an entire small commercial orchard or a substantial portion of a larger orchard.

It was concluded that both rotenone-bearing materials and phenothiazine may be used as substitutes for lead arsenate in the control of cherry fruitflies, altho phenothiazine was less acceptable because of its higher cost and its irritating effect on the skin of the spray operator. The following spray mixture was found to be the most satisfactory:

Derris or cube root (5% rotenone)	2 lbs.
Micronized wettable sulfur (fungicide)	4 lbs.
Soybean flour	¼ lb.
Water to make	100 gals.

For effective control with sprays containing the rotenone-bearing materials, three applications, properly timed in relation to fruitfly emergence, were necessary. It appeared desirable in most instance to synchronize the spray applications with the emergence of *Rhagoletis cingulata*. In Columbia County, N. Y., over a five-year period, the emergence of this species began between June 4 and 11 and ended between June 24 and July 8. After allowing for a pre-oviposition period of about 12 days, it was found advisable to apply the first fruitfly spray in this locality on about June 10, followed by two additional sprays at intervals of 8 to 10 days. *R. fausta*, which emerges earlier, May 26 to June 14 according to limited observations, is partially controlled by the earlier shuckfall spray of lead arsenate and is relatively less abundant when *R. cingulata* is present. *R. fausta* was never found infesting English Morello cherries.

On late-maturing varieties, such as English Morello, it was found possible to reduce costs by substituting basic zinc arsenate (1 pound

[1]These studies were conducted in cooperation with the Station in orchards near the Hudson Valley Fruit Investigations Laboratory, Poughkeepsie, N. Y.

per 100 gallons) for the derris or cube at the time of the first fruitfly spray, provided the shuck spray (used earlier) contained not more than 1 pound of arsenical per 100 gallons.

Two sprays containing basic zinc arsenate at reduced dosages decreased insect injury but did not control fruitflies as effectively as the rotenone-bearing materials and phenothiazine. Xanthone did not give adequate control.

STUDIES ON THE CONTROL OF THE GRAPE-BERRY MOTH

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F. Z. HARTZELL, *Chief in Research (Entomology)*

A renewed interest in the control of the grape-berry moth, *Polychrosis viteana* Clem., has developed on the part of grape growers and processors in Chautauqua County during the past few years following an increase in abundance of this insect. An investigation of methods of control has been carried out in this area by the Station during 1939, 1940, and 1941. The work has resulted in the development of a spray program that has given favorable results.

Prior to 1937 outbreaks of the berry moth were short lived, progressing to a peak and then declining suddenly, all within a period of about two years. The present high level of infestation has prevailed over a period of five years and the insect has spread extensively, damaging many vineyards not previously affected. Infestations have usually been heavier in vineyards near Lake Erie than on the gravelly ridges farther inland. Great variations in fruit injury are found between different sections of almost any infested vineyard. These variations in infestation between localities and between sections of the same vineyard are due to several factors, one of which may be the amount of snow cover present during winter months. Infestations have been observed to be most serious where natural or artificial windbreaks have caused the accumulation of snow. Such a cover apparently offers greater protection for the pupae of the berry moth which spend the winter on the surface of the ground.

Insecticide programs using both arsenicals and plant derivatives as toxicants were tested, principally in the form of sprays. Preliminary tests were also made with dusts. Both "straight" and "split" spray programs were tested in a schedule of three to four treatments. Split programs were employed in an attempt to eliminate the danger of excessive spray residues on fruit which result when a full schedule of arsenical sprays is used. An indication of the efficiency of a few of the materials and combinations tested is given in Table 1.

To insure proper spray coverage a special boom equipped with an efficient hood was developed (Fig. 1). The boom is in the form of an inverted "U" which permits thoro coverage on both sides of a row in one operation. The hood was used to nullify the effect of the wind.

Of the various spray programs tested, the one given below will combine efficiency with a reasonable expectancy of avoiding excessive spray deposit at harvest:

Applications 1 and 2		Applications 3 and 4	
Calcium arsenate	3 lbs.	Black Leaf 155 Concentrate (14% nicotine)	3 lbs.
*{ Copper sulfate	2 lbs.		
{ Hydrated lime	4 lbs.		
Resin fish-oil soap	2 lbs.	Resin fish-oil soap	8 oz.
Kerosene	½ pt.		
Water to make	100 gals.	Water to make	100 gals

*2-4-100 bordeaux used as an arsenical corrective.

TABLE 1.—EFFICIENCY OF VARIOUS SPRAY MATERIALS USED AGAINST THE GRAPE-BERRY MOTH.

INSECTICIDES USED AND NUMBER OF APPLICATIONS*	NUMBER OF TESTS	AVERAGE PERCENTAGE OF GRAPE BERRIES INFESTED		AVERAGE PERCENTAGE CONTROL
		Untreated	Treated	
Straight Schedules				
Lead arsenate, 4	3	14.2	2.1	85.1
Calcium arsenate, 4	5	20.6	4.9	81.2
Black Leaf 155 Concentrate, 4	2	22.7	7.6	65.0
Black Leaf 155 Concentrate "micronized", 4	1	23.5	3.0	87.2
Phenothiazine "micronized", 4	1	16.6	4.8	71.2
Split Schedules				
Calcium arsenate, 1 and 2 Black Leaf 155 Concentrate, 3 and 4	6	25.9	5.4	79.1
Calcium arsenate, 1, 2, and 3 Black Leaf 155, 4	3	22.6	3.3	84.3
Calcium arsenate, 1 and 2 Ground derris root, 3 and 4	1	33.4	7.0	79.0

*All materials were used at the rate of 3 pounds per 100 gallons of spray, except phenothiazine which was used at the rate of 2 pounds per 100 gallons and ground derris root (4% rotenone) which was used at the rate of 4 pounds per 100 gallons. Lead arsenate and calcium arsenate sprays also contained bordeaux mixture (2–4–100), 2 pounds of resin fish-oil soap, and ½ pint of kerosene per 100 gallons. Black Leaf 155 Concentrate (14% nicotine) sprays contained 8 ounces of resin fish-oil soap per 100 gallons. Ground derris root sprays contained 4 ounces of Grasselli Sticker-Spreader per 100 gallons.

FIG. 1.—BOOM AND HOOD DEVICE TO INSURE EFFICIENT SPRAYING OF VINES FOR THE GRAPE-BERRY MOTH.

A schedule of four sprays is suggested for the average infested vineyard, altho three applications may be sufficient where a light infestation occurs. In vineyards where very heavy populations are encountered it may be necessary to use five treatments.

Thoro spraying is essential and in order to insure this the spray should be applied at the rate of 175 to 200 gallons per acre. A pump pressure of between 350 and 400 pounds is desired.

The proper timing of sprays is also important. In most years the first treatment is applied immediately after blossoming, followed by a second treatment 10 days later. The third treatment is directed against the second brood and should be applied sometime between the last week of July and the second week of August, depending on seasonal conditions. The fourth application, when required, is made 10 days later. To determine the most satisfactory dates for applying these treatments, detailed observations on the development of the grape-berry moth in representative localities are necessary each season.

STUDIES OF ROTENONE SPRAYS FOR CABBAGE WORM CONTROL

G. E. R. HERVEY, *Associate in Research* (*Entomology*)

THE use of rotenone-bearing materials for the control of cabbage worms has become a well-established procedure. Standard recommendations include either a dust containing ¾ or 1 per cent rotenone or a spray suspension consisting of 4 pounds of derris or cube powder (4 or 5 per cent rotenone) per 100 gallons of water. These formulas have been tested extensively and have generally proved very effective. In addition to these materials there are numerous rotenone extracts on the market which, in some cases, have been recommended by the manufacturers for cabbage worm control. In 1941 an opportunity occurred to test two of these materials in comparison with a derris powder spray suspension. The procedure consisted of comparing the commercial preparations with a derris spray containing 1 pound of derris (4.8 per cent rotenone) to 100 gallons of water, all sprays having the same rotenone content. The standard treatment of 4 pounds of derris to 100 gallons of water was included for comparison in the experiment, altho it was thought impractical to attempt to use the extracts at this rotenone strength owing to the high concentrations that would be required.

The experiment was conducted in a field of Danish type cabbage which was set out about the middle of June and harvested the first week in November. The treatments were applied with a power sprayer with a portable two-row boom having four nozzles per row. Approximately 180 gallons of material were used per acre for each application. It was applied at a pressure of 300 pounds. Applications were made on August 6, August 14, and August 28. The plats were two rows wide and 210 feet long. Each treatment was replicated four times and arranged in randomized blocks. There was a moderate infestation of the imported cabbage worm and the cabbage looper. The imported worm was predominant during August and the cabbage looper was the more abundant species during September.

The relative toxicity of the materials was determined by an estimate of the amount of damage sustained by each plant in each plat. This estimate was made by grading the plants into four groups, *viz.*, clean, light, moderate, and severe. In order to overcome the error which is inherent in such a procedure, the records were taken by two observers independently and these were averaged. The total number of plants counted for each treatment was approximately 900. The first count was made on September 3 and a second count on October 9 on which latter date insect activity was practically over for the season.

The data from this experiment are summarized in Fig. 1. The materials used were as follows: (1) Derris powder (4.8 per cent rotenone and 16 per cent total extractives) 4 pounds to 100 gallons of water; (2) derris powder, 1 pound to 100 gallons of water; (3) Syn-

tone, a rotenone extract containing 2.8 per cent rotenone, used at the rate of 1 part to 454 parts of water; (4) NNOR, a rotenone extract containing 1 per cent rotenone, used at the rate of 1 part to 160 parts of water; (5) Special Agicide Concentrate, a commercial derris suspension used at the rate of 1 part to 98 parts of water.

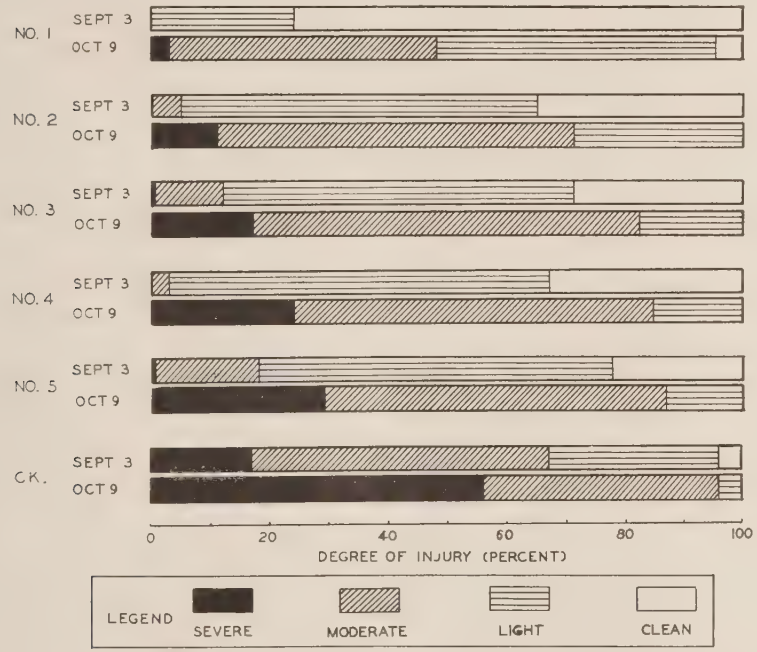

FIG. 1.—THE DEGREE OF CABBAGE WORM INJURY SUSTAINED BY CABBAGE PLANTS WHEN TREATED WITH VARIOUS ROTENONE SPRAYS.

An examination of Fig. 1 shows that in the record taken on September 3 the derris spray, 4 pounds to 100 gallons of water, was the most effective treatment. This is to be expected since it contained four times as much rotenone as the other treatments. In this plat 75 per cent of the plants were free from injury, while the 25 per cent showing slight injury were not commercially damaged. The differences between the derris spray where 1 pound was used and Syntone, NNOR, and Agicide in the record taken on September 3 were not very marked. It is probable that the derris and the NNOR were about equal in effectiveness with the other two slightly inferior. Between the time the first record was taken and the second on October 9 considerable insect feeding took place and all plats showed an increased amount of injury. The derris spray, 4 pounds to 100, was

still the most effective combination. The relative effectiveness of the other four treatments changed somewhat during this period. The derris spray, 1 pound to 100, seems to have prevented the insect attack appreciably better than Syntone, NNOR, or Agicide. The last three materials were decreasingly effective in the order named.

In this experiment an attempt has been made to compare a derris powder spray suspension with two commercial extracts and a commercial derris suspension, all used at the same rotenone content, against cabbage worms. It would appear from a record of the injury to the plants taken a few days after the last application was made that there was not a very significant difference in toxicity between these materials. A second count taken over a month later, however, showed that the derris spray suspensions were more effective than the extracts, indicating a superior residual effect for materials of the former type.

RECENT EXPERIMENTS TO CONTROL THE SCURFY SCALE

O. H. HAMMER, *Assistant in Research* (*Entomology*)

APPLE growers in the Red Hook-Tivoli area of eastern New York have been plagued for several years by an insidious infestation of the scurfy scale, *Chionaspis furfura* Fitch. Efforts to control this pest have met with varying degrees of success, depending on the materials used and the technic of the spray operators. Extensive experiments have demonstrated that dormant oil emulsions used alone and with certain of the so-called dinitro toxicants are among the most effective sprays available for use against this pest, altho their use has sometimes been accompanied by injury to the trees. Recent experiments have been conducted in an effort to develop spray formulas which would insure adequate control of the scale with little or no tree injury.

Some of the spray formulas tested against the scurfy scale during 1939, 1940, and 1941, together with the resultant control obtained, are presented in Table 1. A paraffin-type petroleum oil (*Diamond Tree Spray Oil*) was used in these experiments. The two emulsifiers used were lignin pitch (Goulac) and a proprietary mixture of blood albumin mixed with a carrier in the proportions of 1 to 3, respectively. Enough of this latter commercial mixture was used to give 2 ounces of blood albumin per 100 gallons of spray.[1] The oil emulsions were made by the so-called tank-mix method. All sprays were applied in the dormant period, usually in early spring before the start of apple bud development.

The data in Table 1 indicate that tank-mixed oil emulsions containing up to 6 per cent oil, with lignin pitch as the emulsifying agent, or sprays containing only dinitro toxicants in water gave control efficiencies below 95 per cent, which is considered to be the minimum practical level of acceptability against moderate and heavy scurfy scale infestations. Oil sprays emulsified with blood albumin gave good control when 3 per cent or more of oil was used alone or in combination with dinitro toxicants, the only exception being a lower efficiency when 4 ounces of dinitro-ortho-cyclo-hexylphenol were used per 100 gallons of a 3 per cent oil emulsion. The better control obtained with 3 per cent oil when blood albumin was used as the emulsifier is attributed to the more effective oil-depositing properties imparted by this material. Altho it appears unnecessary to use dinitro toxicants with dormant oil emulsions for scurfy scale control, such a combination is desirable when it is also necessary to control the bud moth and apple aphids, all of which are very susceptible to the dinitro materials.

None of the experimental formulas shown above caused permanent tree injury, altho some retardation of development occurred when more than 3 per cent oil was used alone or with added toxicants.

[1]Further information concerning the use of blood albumin is presented in another article in this bulletin (pages 15 and 16).

TABLE 1.—RESULTS OF SCURFY SCALE CONTROL EXPERIMENTS IN THE HUDSON VALLEY.

MATERIALS AND AMOUNTS USED WITH WATER TO MAKE 100 GALLONS			PERCENTAGE EFFICIENCY OF SCURFY SCALE CONTROL		
Oil gallons	Emulsifying agent*	Dinitro toxicant, ounces	1939	1940	1941
A. Without Dinitro Toxicants					
6	LP	None	87.27	90.20	——
3	LP	None	65.52	——	——
6	BA	None	——	99.89	——
4	BA	None	——	——	99.57
3	BA	None	——	97.76	99.29
B. With Dinitro-o-cyclo-hexylphenol (Oil-soluble, Powdered Form)					
3	BA	4	——	92.28	——
3	BA	8	——	98.32	——
3	BA	10	——	98.88	98.08
C. With Sodium-dinitro-o-cresylate (Elgetol, a Water-soluble Liquid)					
4	BA	6.9	——	99.40	——
3	BA	13.8	——	99.78	98.37
None	None	13.8	——	82.44	——
D. With Dinitro-o-cresol (Oil-soluble, Powdered Form)					
3	BA	9.6	——	——	98.37
None	None	9.6	——	——	26.33
None	None	11.4	——	57.49	——

*LP = Lignin pitch (Goulac), 12 ounces per 100 gallons; BA = Blood albumin mixture; 8 ounces (actually containing 2 ounces of blood albumin) per 100 gallons.

It was observed, however, that any differences between sprayed and unsprayed trees disappeared within the first three weeks of spring growth. Those attempting to control the scurfy scale should exercise particular care in the preparation and application of the sprays if poor control and severe tree injury are to be avoided.

INSECTICIDES FOR ORIENTAL FRUIT MOTH CONTROL

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WHEN the oriental fruit moth first became established in New York, this Station thoroly investigated the use of insecticides for controlling the pest. It was then concluded that insecticides were largely ineffective. Subsequent efforts have therefore been largely devoted to the study of parasitic insects as a means of control. Recently, several new insecticides of possible value for fruit moth control have appeared. Three of these materials were tested against late brood worms on peaches in the Hudson Valley in 1941.

The tests were conducted in a 4-year-old Elberta orchard in which 50 per cent of the fruit was estimated to have been injured by the fruit moth during the previous season. When the 1941 tests were begun numerous growing tips had been attacked by first brood larvae and some fruit feeding by second brood larvae was present. The materials used are listed in Table 1.

TABLE 1.—EFFICIENCY OF SPRAY MATERIALS USED AGAINST THE ORIENTAL FRUIT MOTH IN THE HUDSON VALLEY IN 1941.

TREATMENTS*	SECOND BROOD		THIRD BROOD	
	Percentage injured fruit	Percentage control	Percentage injured fruit	Percentage control
Oil-sulfur dust	9.62	46.55	1.65	66.30
Xanthone spray	14.46	19.72	1.36	72.26
Fixed nicotine spray	12.53	30.43	2.09	57.25
Check	18.01	——	4.90	——

*The insecticides were prepared as follows:
Oil-sulfur dust: Sulfur, 57 per cent; petroleum oil, 5 per cent; inert ingredients, 38 per cent. Xanthone spray, 2 pounds Xanthone per 100 gallons. Fixed nicotine spray, 3 pounds of 14 per cent nicotine per 100 gallons.

Starting July 24, applications of oil-sulfur dust were made at weekly intervals thru August 28. Spray treatments were started one week later, on July 31, and were also continued at weekly intervals until August 28, making a total of six dust and five spray applications. It was intended that the treatments should be stopped a week before the fruit was harvested, but first pickings were made on September 2 and 3, only four to five days after the last applications had been made. All three materials left unsightly residues on the peaches which interfered with the development of normal color. The sprayed fruit, especially, had a dull, greenish hue, making it appear unripe when it was actually mature. Running the fruit thru a brushing machine removed much of the oil-sulfur dust residue but failed to improve the

appearance of the sprayed fruit. The residue, together with the poor color, made the sale of the fruit from a roadside stand difficult.

The fruit moth infestation failed to attain as high proportions as in the previous season and, contrary to expectations, the third brood larvae did much less damage to the fruit than those of the second brood. Altho the treatments were timed to control the third brood and were applied after second brood injury had started, the data indicate that some control of second brood larvae was exerted. As might be expected, the oil-sulfur dust treatment, having been started earlier, gave more control of the second brood than the sprays.

The performance of these three insecticides in the preliminary tests described above represents no substantial improvement, in either fruit moth control or the avoidance of unsightly residues, over the results obtained with other materials tested earlier in western New York.[1] If the 1941 condition in respect to relative injury by the second and third broods is typical for eastern New York, the question of control by insecticides will bear reinvestigation, with emphasis placed on combating the second brood. Until further study of that phase of the problem is made, however, there is little to justify the use of insecticides for control of the oriental fruit moth on peaches in this State.

[1]Daniel, Derrill M. Oriental peach moth experiments. *Jour. Econ. Ent.*, **24**, *317–318. 1931.*

FIELD IDENTIFICATION OF FIVE LEAF ROLLERS FOUND IN APPLE ORCHARDS

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A number of species of leaf rollers are found in western New York apple orchards. The fruit-tree leaf roller and the red-banded leaf roller are present each year in sufficient numbers to constitute a real problem for fruit growers. The fact that the larvae of several distinct species are present in the orchard at the same time creates a confusing situation unless it is possible to identify each kind. Since the larval stages of a number of these species have not been previously described and the life histories of some have been unknown, an effort was made to conduct life history and morphological studies of all forms occurring in experimental orchards. To date, fairly complete studies of five species have been made and the important diagnostic characters of eggs, larvae, and adults are shown in Table 1. Other species, found in 1941, are not included because their seasonal histories have not been fully worked out. Forms may therefore be found in orchards which are not included in the table.

The species considered in this discussion are (1) the fruit tree leaf roller, *Cacoecia argyrospila* Walker, a common pest of apple in western New York; (2) the three-lined leaf roller, *Pandemis limitata* Robinson; (3) the oblique-banded leaf roller, *Cacoecia rosaceana* Harris; (4) the four-lined leaf roller, *Eulia quadrifasciana* Fernald; and (5) the red-banded leaf roller, *Eulia velutinana* Walker, which is quite abundant in certain years and is usually an important pest in some apple orchards each summer. All these species feed on other trees in addition to apple, but the descriptions of eggs and larval stages are all based on specimens reared on the apple in western New York.

Since spring feeding by the larvae of four of these species is usually more closely related to bud development stages than to calendar dates, the former, as based on apples of the Rhode Island Greening variety, are given in the table. It will be noted that in all five species the body of the larva is flattened. Altho this does not aid in separating the five species from each other, it does serve to distinguish any of these larvae from those of green fruit-worms (*Graptolitha* spp.) which are present on apples during the spring months and in which the body is cylindrical.

The time of appearance on the foliage has been found to be a very important, perhaps the most important, factor for separating species which have similar larval characteristics. Species which might be very difficult to separate in the presence of other similar larvae are easily distinguished by the fact that they are present when other species are known definitely to be in some other stage of development. For example, fruit-tree leaf roller larvae, when immature, have black thoracic shields and black heads almost identical to those found on immature larvae of the oblique-banded leaf roller. The latter emerge

TABLE 1.—TENTATIVE KEY FOR FIELD IDENTIFICATION OF FIVE SPECIES OF LEAF ROLLERS.

CHARACTERISTICS	FRUIT-TREE LEAF ROLLER, *Cacoecia argyrospila* Walker	THREE-LINED LEAF ROLLER, *Pandemis limitata* Robinson	OBLIQUE-BANDED LEAF ROLLER, *Cacoecia rosaceana* Harris	RED-BANDED LEAF ROLLER, *Eulia velutinana* Walker	FOUR-LINED LEAF ROLLER, *Eulia quadrifasciana* Fernald
Number of broods	One	Two	Two	Two	One
Egg mass:*					
Color	Gray	Yellow-green	Yellow-green	Yellow-green	Greenish-brown
Shape	Elliptical	D-shape	Circular	Irregular blotches	Irregular
Location	Small twigs	Upper leaf surface	Usually upper leaf surface	Smooth bark, usually on twigs	Foliage
Number of eggs per mass, approximate	60	50	150 to 200	40 to 50	50
Time of oviposition:					
Overwintering or first brood	Late June†	Mid-June	Mid-June	Late April	Mid to late June
Summer or second brood	———	Early August	Early August	Mid to late July	———
Time of hatching:					
Overwintering or first brood	Opening to pink stage of buds‡	Mid-August	Mid-August	Late April to late May	Mid-June
Summer or second brood	———	Late June	Late June	Late July to early August	———
Larva:§					
Time present on trees:					
Overwintering or first brood	Opening of buds until after calyx	August to May	August to May	Late May to late June	Late June to late May following year
Summer or second brood	———	Late June to mid-July	Late June to mid-July	Early August to October	———
Webbing	Tie blossoms and leaves together	Tie leaves together	Tie leaves together	Fasten leaves to fruit	Fold leaves together
Feeding on fruit	Gouge deeply in young fruit	Not observed	Gouge deeply in young fruit	Engrave fruit very shallowly	Not observed
Damage to fruit	Very important	Not observed	Incidental	Very important	Not observed
Occurrence	Abundant	Incidental	Incidental	Moderately to severely abundant	Incidental
Sensitive to touch	Moderately	Moderately	Moderately	Extremely	Moderately
Length, mature (inches)	1	¾	¾ to 1	¾	½ to ¾
Shape, mature‖	Flattened	Flattened	Flattened	Flattened	Flattened
Head:					
Color, immature	Shining black	Brown, never black except when overwintering	Black	Straw-colored	Apple-green, head often tinged with reddish brown
Color, mature	Black or dark brown	Apple-green tinged with red	Variable, usually chestnut-brown or deep brown	Straw-colored	Same as immature stages

Thoracic shield:					
Color, immature	Shining black	Brown to greenish-brown anterior corners darker	Black	Straw-colored	Apple-green
Color, mature	Olive-green with dark lateral band on margin	Greenish-brown	Olive-green with darker posterior margin	Apple-green	Apple-green
Body:					
Color, immature	Apple-green	Varying shades of green	Varying shades of green	Yellow-green, two light-colored longitudinal stripes on abdomen	Apple-green
Color, mature	Apple-green	Apple-green to yellow-green	Apple-green, often olive-green	Same as immature stages	Apple-green
Adult:					
Size	About same as codling moth	About same as codling moth	One inch wing-spread, largest of leafroller moths	Slightly smaller than codling moth	Slightly smaller than eye-spotted bud moth
Time of appearance:					
Overwintering or first brood	Late June	Early June	Early June	Late April	Mid-June
Second or summer brood	———	Late July to early August	Late July to early August	Mid to late July	———
Color and markings	Forewings mottled with shades of brown. Two creamy white spots on the anterior margin of each forewing	Forewings light brown with three pale-yellow lines extending across the wings	Light brown with dark brown bands extending obliquely across each wing. Forewings deeply lobed giving bell appearance in natural position	Forewings cream with reddish brown bands extending obliquely across wing, widening toward margin	Forewings lemon-yellow with orange-red dots. Two narrow orange-red bands on each forewing
Hibernation:					
Stage of insect	Eggs	Partly grown larvae in silken hibernacula, either in crotches of twigs or in leaf axils	Partly grown larvae, probably in silken hibernacula in crotches of twigs	Pupae in fallen leaves	Partly grown larvae in silken hibernacula on twigs or trunk
Time of entrance	Mid to late June	October	October	October	August
Time of emergence	Opening to pink stage of buds	Prepink stage of buds	Prepink stage of buds	April	Prepink stage of buds

*These five species deposit eggs in masses.
†All dates are for western New York.
‡All bud stages are for Rhode Island Greening apples.
§The larvae of these five species feed singly and are never gregarious. All feed on other plants, but the table is based on observations made on apple. The flattened appearance of these five species distinguish them from green fruit-worms which are cylindrical.

from hibernation in the spring as third- or fourth-instar larvae and are even further developed by the time the fruit-tree leaf roller larvae are emerging from egg masses. Thus, the occurrence of the same stage of these similar forms at the same time is not likely to happen except for an occasional overlapping of different instars.

From the table it is possible to make fairly accurate determinations of these five leaf roller larvae thruout the season. This information should be of value to research workers, spray service specialists, and fruit growers.

PRE-FOLIAGE TREATMENTS FOR CONTROL OF BUD MOTH

F. Z. HARTZELL, *Chief in Research (Entomology)*

DURING the past decade the writer has been investigating the control of the eye-spotted bud moth, *Spilonota ocellana* Schiff., by the use of pre-foliage treatments. With the exception of nicotine treatments, which extend over a longer period, only field tests conducted from 1936 to 1941 are included in this report. The 24 orchards used one or more seasons were located in the western New York counties of Wayne, Ontario, Seneca, Monroe, and Orleans, the majority being in Wayne. A total of 4,615 apple trees were either sprayed or served as checks, not counting the orchards and trees used in earlier nicotine experiments. Tests were made with 118 important mixtures, the more promising being tested 2 to 5 years. If the variations in emulsifiers are included, more than 200 different mixtures were investigated, most of which were with dinitro insecticides. Many of the mixtures were either not sufficiently effective or consisted of concentrations which cannot be regarded as safe for

TABLE 1.—CONTROL OF BUD MOTH WITH NICOTINE USED IN LIME-SULFUR AND LUBRICATING OIL.*

NICOTINE, PINTS†	PERCENTAGE CONTROL	
	Lime-sulfur, 2½ gallons	Lubricating oil, 3 gallons
1	67 (5)‡	70 (12)
1½	67 (3)	77 (3)
2	73 (6)	78 (13)

*The amounts of insecticide indicated were used per 100 gallons of spray mixture.
†Black Leaf 40 supplied by Tobacco By-Products and Chemical Corporation.
‡Numbers in parentheses refer to the number of tests made in different orchards or on different varieties in the same orchard.

TABLE 2.—CONTROL OF BUD MOTH WITH COAL TAR OIL AND TAR-LUBRICATING OIL EMULSIONS.*

MATERIALS	PERCENTAGE CONTROL					
	No lubricating oil	No lubricating oil	No lubricating oil	No lubricating oil	3 gals. of lubricating oil	2½ gals. of lubricating oil
Coal tar oil, gals.†	2½	3	3¾	4½	2½	3
Control, per cent	59 (1)‡	67 (6)	68 (10)	76 (9)	77 (6)	80(5)

*The amounts of insecticide indicated were used per 100 gallons of spray mixture.
†Produced by various manufacturers.
‡Numbers in parentheses refer to the number of tests made in different orchards or on different varieties in the same orchard.

apple buds, at least during certain seasons, so are not included in the tables.

Tables 1 to 4 give the results with mixtures that are or have been of greatest interest to growers. Since only a relatively few tests per season can be made in any orchard, and also because all the experiments were not carried out in any one year, some of the averages in the table are slightly discordant, so small differences in percentage control should not be considered too important.

TABLE 3.—CONTROL OF BUD MOTH WITH OIL-SOLUBLE AND SOME WATER-SOLUBLE DINITRO INSECTICIDES.*

MATERIALS	TOXICANT, OUNCES				
	6.4	8	10.4	12.4	14.4
Percentage Control with Dinitro-o-cyclohexylphenol†					
Lubricating oil:					
2½ gals.	76 (11)‡	84 (2)	89 (3)	93 (16)	———
3 gals.	93 (3)	84 (9)	95 (7)	98 (8)	95 (19)
Percentage Control with Dinitro-o-cresol†					
Lubricating oil:					
2½ gals.	———	———	90 (2)	88 (3)	———
3 gals.	94 (2)	92 (2)	90 (1)	97 (7)	———
3 gals.	91 (2)§	———	———	———	
Soda ash + spreader	———	———	———	82 (4)	———
Niagara, water-soluble§	———	———	———	84 (1)§	———

*Amounts of insecticide indicated were used in 100 gallons of spray mixture.
†Supplied by Dow Chemical Company, Midland, Mich., except where otherwise stated.
‡Numbers in parentheses refer to number of tests made in different orchards or on different varieties in the same orchard.
§Supplied by Niagara Sprayer and Chemical Company, Middleport, N. Y.

TABLE 4.—PERCENTAGE CONTROL OF BUD MOTH WITH SODIUM DINITRO-O-CRESYLATE.*

LUBRICATING OIL, GALLONS	DINITRO-O-CRESOL, OUNCES†			
	6.9 (¼)	13.8 (½)	20.6 (¾)	27.5 (1)
0	79 (2)‡	87 (16)	94 (7)	97 (21)
3	93 (1)	97 (9)	97 (3)	99 (6)

*Amounts of insecticide indicated were used in 100 gallons of spray mixture.
†Figures in parentheses following ounces of toxicant refer to equivalent gallons of Elgetol used. Elgetol was furnished by Standard Agricultural Chemicals, Inc., Hoboken, N. J. It consists of sodium dinitro-o-cresylate and certain materials which are called "penetrants" by the makers.
‡Figures in parentheses following figures of percentage control refer to number of tests made in different orchards or on different varieties in the same orchard.

Nicotine, altho less effective than the dinitro compounds, is still a useful insecticide for bud moth control because of its safeness to buds

in the green-tip and delayed dormant stages. Coal tar oils have now practically disappeared from the orchards chiefly because of their caustic action to the skin of the operators and also for the reason that dinitro insecticides usually give better control of bud moth. Dinitro-o-cyclohexylphenol (here called "phenol" for brevity) in oil has been largely superseded both by dinitro-o-cresol ("cresol" for brevity) in oil and its salts (cresylates) in water because of greater safeness of cresol and cresylates to apple buds and twigs. Cresol in oil, however, may injure buds even tho the oil concentration does not exceed 3 per cent. The sodium salt of "cresol" in oil is about as toxic to the buds as is "phenol" in oil.

Dinitro insecticides may be divided into two classes, namely, oil-soluble and water-soluble. The phenol and cresol compounds mentioned previously are regarded as oil-soluble because they dissolve to the extent of 4 to 5 ounces in 1 gallon of lubricating oil of the grade ordinarily used for dormant spraying and are only slightly soluble in water. By combining phenol or cresol with certain chemicals, water-soluble compounds are produced which are known as cresylates.

From the standpoint of insecticidal properties, the oil and cresol have the advantage over water-soluble cresylates in being effective on a larger number of species of insects. The sodium cresylate is very effective against bud moth, aphids, and oystershell scale and has proved much less toxic to lateral buds than is true of oil and cresol. It should be noted that to be equally effective in water alone the cresol content should be from 1½ to 2 times that when used in oil. Because of their effectiveness on insects and safeness to buds, sprays containing water-soluble cresol are preferred by many growers to those containing oil and cresol where such pests as San Jose scale, fruit-tree leaf roller, and red mite are not present.

A well-known brand of sodium dinitro-o-cresylate, Elgetol, containing so-called "penetrants", has been tested since 1937 and found to be very effective against the bud moth and certain other insects (Table 4). This material is prepared in the factory and sold in paste form. A number of water-soluble cresylates other than the sodium compound have been prepared by several manufacturers. These were tested in 1941 and several of the compounds gave promising results. More experimental evidence is needed, however, before general recommendations can be given. Not all of these water-soluble compounds proved effective against bud moth.

A well-known brand of dry cresol, Dow DN Dormant, can be converted into a water-soluble form in the spray tank by the use of certain chemicals. A number of tests were made during 1940 and 1941 with such tank-mixed materials. The tests in 1940 were of a preliminary nature so the results were not so pronounced as in 1941. The control of bud moth in 1941 with such mixtures appears promising, but general recommendations cannot be made on one season's studies.

It should be noted that the time of application for the different materials is very important. Nicotine with lubricating oil should be

applied in the green-tip or early delayed dormant stages of the buds, while nicotine with lime-sulfur should be used at the early delayed dormant stage for the control of bud moth. Dinitro sprays with lubricating oil and also coal tar oil should be applied in the spring while the buds are dormant. Water-soluble cresylates are also to be used while the buds are dormant. Experiments during the past three years on a large number of trees have indicated that Elgetol when used in the green-tip stage at a concentration of not more than ¾ gallon (21 ounces of DNOC) per 100 gallons, is reasonably safe since no injury occurred in any of the tests. Tank-mixed, water-soluble cresylates also produced no injury in 1941, altho it should be noted that none were used in excess of 12 ounces of DNOC per 100 gallons.